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Calculation of Day-Night Levels (Ldn) Resulting from Civil Aircraft Operations

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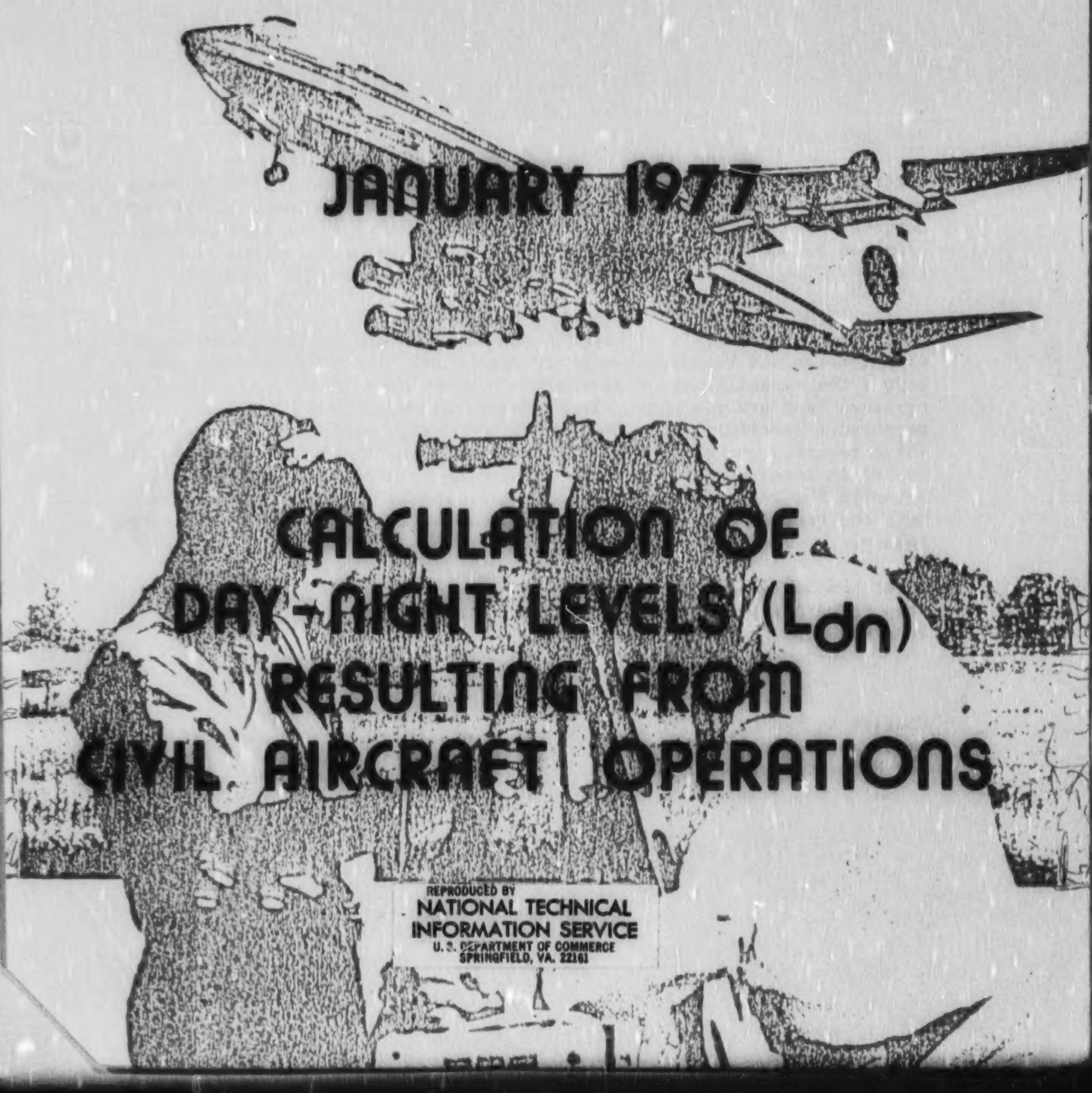

JANUARY 1977

CALCULATION OF DAY-NIGHT LEVELS (L_{dn}) RESULTING FROM CIVIL AIRCRAFT OPERATIONS

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Dear Reader:

Aircraft noise is now a significant problem for many people living near airports. Part of the solution to this problem can be found in abatement actions which are specific to individual community/ airport situations. Adoption of such airport specific actions must be preceded by the analysis and depiction of both current situations and all feasible abatement options.

Until now, the analysis of noise abatement options has often been equated with complex and expensive computer operations, the cost of which may be beyond the capabilities of some airport proprietors, involved communities, or local land use planners. This manual will allow one to calculate, on an airport specific basis, the day-night average sound level (L_{dn}) which results from civil aircraft operations and thus predict the noise impact in areas near the airport. This "desk calculation" of aircraft noise levels was adapted from the type of computer systems now in use by both the Federal Aviation Administration and the Environmental Protection Agency.

We at EPA believe that this manual desk calculation process is a major step forward with respect to aviation noise abatement and compatible land use planning.

Charles L. Elkins
Deputy Assistant Administrator
for Noise Control Programs

EPA 550/9-77-450

CALCULATIONS OF DAY-NIGHT LEVELS (L_{dn}) RESULTING FROM CIVIL AIRCRAFT OPERATIONS

JANUARY 1977

Prepared For:

U.S. Environmental Protection Agency
Office of Noise Abatement and Control

Under Contract No. 68-01-3218

This report has been approved for general availability. The contents of this report reflect the views of the contractor, who is responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policy of EPA. This report does not constitute a standard, specification, or regulation.

SUMMARY

A method is described for calculating values of Day/Night Levels (L_{dn}) at a point due to aircraft operations from civil airports. Two levels of sophistication are detailed -- at the basic level, such factors as type of takeoff and landing procedures are considered, but aircraft range and non-standard approach glide slopes are excluded; the detailed method takes account of the latter parameters. The procedure is to determine distances between the point in question on the ground and the aircraft flight tracks and runway. A series of charts provided in the report give L_{dn} values for different types of aircraft in terms of these distance parameters. An adjustment is made to the noise levels for each class of aircraft to take account of the number of operations, and these adjustment levels are then added logarithmically to producce an overall noise level. This method is not suitable for generating noise contours (lines of equal L_{dn} value) although a method is described for estimating area and size of any given contour.

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CALCULATION OF DAY/NIGHT LEVELS DUE TO CIVIL AIRCRAFT FLIGHT OPERATION

SECTION I

INTRODUCTION

This manual presents procedures and information for calculating the day/night noise level (L_{dn}) due to flight operations in the vicinity of civil airports. Use of this procedure and aircraft noise information presented in this manual will enable you to estimate the day/night noise level at specific ground locations resulting from aircraft takeoffs and landings at an airport. Charts are provided in the manual which provide noise information on most civil aircraft currently operating in the country. Noise charts are presented for takeoff and landing operations including special noise abatement procedures.

The basic steps in calculating day/night levels are relatively simple and straightforward. However, the number of calculations multiply by the number of types of aircraft and the kinds of operations involved, so calculations can be quite lengthy when calculating noise exposure near an airport where the noise is due to operations from several runways by a variety of aircraft.

The handbook provides information for estimating day/night average levels at two levels of precision:

(a) a preliminary assessment when detailed information on aircraft operations is not available and

(b) a detailed assessment when accurate information on aircraft flight operations and flight paths is known.

The latter assessment requires more extensive information on aircraft operations and may be more time consuming to calculate.

This manual has been especially developed for desk calculation of day/night levels values at specific ground locations. The procedures are not intended for developing noise exposure contours around an entire airport since the calculations would generally be too time consuming and laborious. When noise contours over a considerable area are needed, several computer programs are currently available and should be used.[1,2]* The basic noise information provided in this manual is identical to that used in some of the other current computer programs for calculating day/night level contours.

This manual does not include information on military aircraft, hence it cannot be used for calculating L_{dn} values for a military airport or where military aircraft operate from a civil airport; information on noise from ground runup operations is also excluded from the handbook. Noise data are also restricted to fixed wing aircraft, so that noise from helicopter operations cannot be calculated. However, the basic calculation procedures can be extended to cover those aircraft simply by providing separate noise charts for the aircraft not covered in this manual.

This manual does not provide information on criteria, standards or guidelines for interpreting the day/night level

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References are listed together at the end of the text.

in terms of land use or community response. Such information may be found in application guides published by various local, state and federal agencies.

The next section of the manual provides a brief description of the calculation procedure. Section III describes how to calculate L_{dn} values at a point, and Section IV describes a method for determining approximate L_{dn} contours. Section V gives additional procedures for detailed noise assessment or non-standard flight profiles. The noise information to be used in calculating the day/night levels is provided in Appendix A. Appendix B provides background technical information concerning the calculation of noise graphs and basic modeling assumptions and sources of technical information.

SECTION II

OVERVIEW

The day night average sound level (L_{dn}) is a measure of the noise environment at a prescribed location over a 24-hour period. It is equivalent in terms of sound energy to the level of a continuous A-weighted sound level with 10 dB added to the nighttime levels. The L_{dn} may be measured or computed in several ways. If the noise is monitored continuously, the noise levels existing over the 24-hour period can be summed on an energy basis (adding 10 dB to the nighttime levels).

A second approach is adopted for calculating the L_{dn} values due to airport operations. In this approach, the noise contributions from each significant aircraft operation (takeoffs and landings) occurring over a 24-hour period are summed on an energy basis to obtain the L_{dn} value. In this case, the nighttime adjustment may be introduced by either adding 10 dB to the nighttime levels or by *multiplying the number* of nighttime events by 10. This latter procedure is the one adopted in this manual.*

To provide a systematic basis for calculations, aircraft noise intrusions are classified by type of aircraft and type of operations (takeoffs and landings). (The classification for an aircraft is based on the airport noise characteristics and its takeoff and landing capabilities.) An L_{dn} value (called a "partial" L_{dn}) is first

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**Daytime is taken as the period from 7:00 a.m. to 10:00 p.m., nighttime is the period from 10:00 p.m. to 7:00 a.m.*

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calculated for each class of aircraft, taking into account the number of significant operations occurring in the daytime and nighttime. These "partial" L_{dn} values are then summed on an energy basis to obtain the total L_{dn}.

A. Sound Exposure Level (SEL)

The noise exposure contribution from each aircraft operation is described in terms of sound exposure level (SEL). Referring to Figure 1, which shows a typical time pattern of the noise levels existing during an aircraft flyover, the SEL is the A-weighted sound level integrated over the entire noise event and normalized to a reference duration of 1 second. Hence the SEL gives the level of a continuous 1 second signal which contains the same amount of energy as the noise event. The 1 second reference duration acts like a common denominator, permitting the addition of new events of varying durations.

Note that while the SEL is measured in terms of the A-weighted sound level scale, the SEL is generally not equal to the maximum A-level occurring during the noise event (see Figure 1). Most aircraft noise intrusions last more than 1 second, so SEL value will in general be *higher* than the maximum A-level for the same event.

B. Calculation of Partial L_{dn} Values

The L_{dn} for one class of aircraft and mode of operation along one flight track is called the "partial" L_{dn}. For aircraft class, i, and operational mode, j, the partial L_{dn} (i,j) is given by:

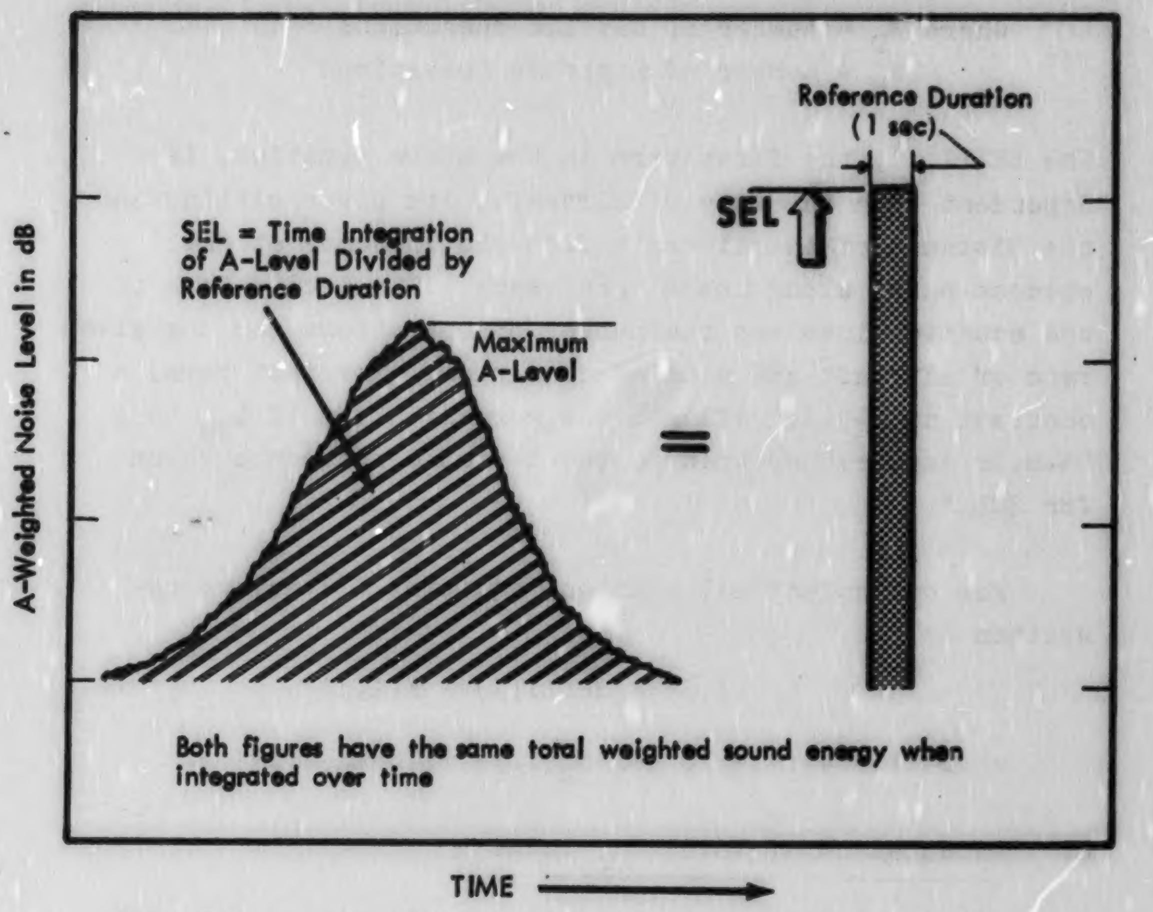
A-Weighted Noise Level in dB
SEL = Time Integration of A-Level Divided by Reference Duration
Maximum A-Level
Reference Duration (1 sec)
SEL
=
Both figures have the same total weighted sound energy when integrated over time
TIME

FIGURE 1. ILLUSTRATION OF SEL CONCEPT

$$L_{dn}(i,j) = SEL(i,j) + 10\log(N_D[i,j] + 10\,N_N[i,j]) - 49.4 \quad (1)$$

where N_D = number of daytime operations

N_N = number of nighttime operations

The SEL(i,j), the first term in the above equation, is dependent upon the type of aircraft, its power setting and the distance of the aircraft from the listener at the closest point along its flight track. The second term of the equation involves the number of operations for the given type of aircraft and mode of operation. The last term, a constant of -49.4, reflects the normalization of L_{dn} to a 24-hour day, rather than to the 1 second reference value for SEL.*

For convenient calculation, equation (1) may be rewritten as:

$$L_{dn}(i,j) = SEL(i,j) - K(i,j) \quad (2)$$

where $K = 49.4 - 10\log(N_D[i,j] + 10\,N_N[i,j])$

C. Calculation of Total L_{dn} Value

After the partial L_{dn} values are calculated for each significant aircraft intrusion, they may be summed on an energy basis to obtain the total L_{dn} due to aircraft

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**The constant of 49.4 equals 10 log(number of seconds in a 24-hour day), or 10 log(86,400).*

operations. Mathematically this is expressed as follows:

$$L_{dn} = 10 \log \sum_{i} \sum_{j} 10^{\frac{L_{dn}(i,j)}{10}}$$

Close to an airport, the L_{dn} contributions from aircraft will generally be much greater than that from other sources, hence the total L_{dn} value due to aircraft will equal the total L_{dn} value for the site. At distances further from the airport, or near other major noise sources, the L_{dn} values resulting from aircraft may not fully account for the noise exposure at the site. In such situations, noise from other sources must be taken into account in determining the total L_{dn} for that site.

D. Calculation Summary

In summary, the major steps in determining the day/night level at any given position near the airport are as follows:

(A) Obtain airport and aircraft operational information to identify types of aircraft and types of operations that contribute to the noise environment at the desired position. Also determine the distance of the aircraft from the ground position and the number of operations for each type of aircraft.

(B) Determine the SEL for *each* contributing noise event using the noise charts given in this manual.

(C) Compute the *partial* L_{dn} value for each significant class of noise events from the SEL and number of events per day and night.

(D) Add *all* the partial L_{dn} values together to obtain the *total* L_{dn} for aircraft operations.

The next section will describe each of the above steps in detail with examples to illustrate applications to real life situations.

SECTION III

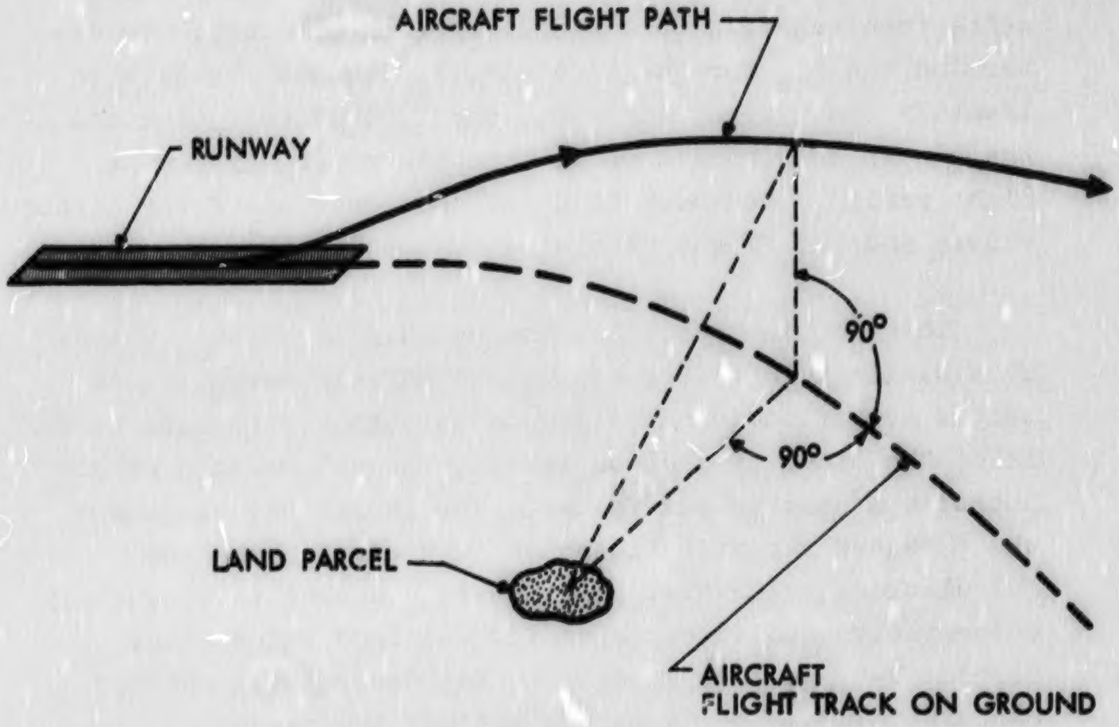
CALCULATION OF L_{dn} VALUES AT A POINT

The basic problem to be solved is illustrated in Figure 2 for the simple case of a land parcel exposed to noise from takeoffs of a single type of aircraft. To determine the L_{dn} for the land parcel, you must be able to identify the type of aircraft, the type of operation and the number of aircraft noise intrusions per day and per night period. You must find out the location of the airport runway and the flight path with respect to the land parcel.

This section describes the calculation of L_{dn} values at a single point. For small land parcels where the expected variation in noise levels throughout the land parcel is of the order of 1 dB or less, calculations at a single position should be sufficient. For larger parcels where the expected variation in noise is greater than 1 dB, calculations at several points may be needed to adequately determine the noise exposure for the land under study. Section V-C provides guidelines for determining whether calculations at one or more positions are needed.

A. Acquire Field Information

Before starting to collect information, a few words of advice may be appropriate for anyone not directly connected with the airport operations. In almost every case, the best source of information is the airport manager; either he will have the information that you want at hand, or he can direct you to someone who has this information. If the airport has a control tower, the FAA tower personnel will also be a major source of information, and the airport manager will probably pass your requests on to them.



PROBLEM: TO FIND DAY-NIGHT LEVEL (L_{DN}) FOR LAND PARCEL DUE TO AIRCRAFT OPERATIONS FROM AIRPORT

FIGURE 2. BASIC SITUATION FOR CALCULATION OF DAY-NIGHT AVERAGE LEVELS DUE TO AIRCRAFT

This report also suggests alternate sources of information, if for any reason you wish to work independently of the airport manager.

Data acquisition involves the following six steps:

1. Determine the physical layout of the airport runways and the length of the runways for the flight paths of concern.

Runway descriptions are given in FAA Form 5010[3] and instrument approach prcedures published by the National Ocean Survey and Jeppesen[4,5]. Many airports will also maintain plans containing runway information, and most airports are also shown in Coast and Geodetic Survey (C & GS) maps. Whatever the source, a check should be made to be sure that the airport information is current.

2. Determine the location of the major flight tracks over the ground and the distances D_1 and D_2.

The path of the aircraft project on the ground is called the track. This track must be located to determine actual distances from the land parcel to the aircraft in flight. Once the track is determined, the distances D_1 and D_2, detailed in Figures 3 and 4, should be calculated for each track.

For takeoffs, shown in Figure 3, D_1 is the distance along the flight track from the start of the takeoff roll to a perpendicular drawn from the flight track to the point where the L_{dn} is to be determined. If the flight track is

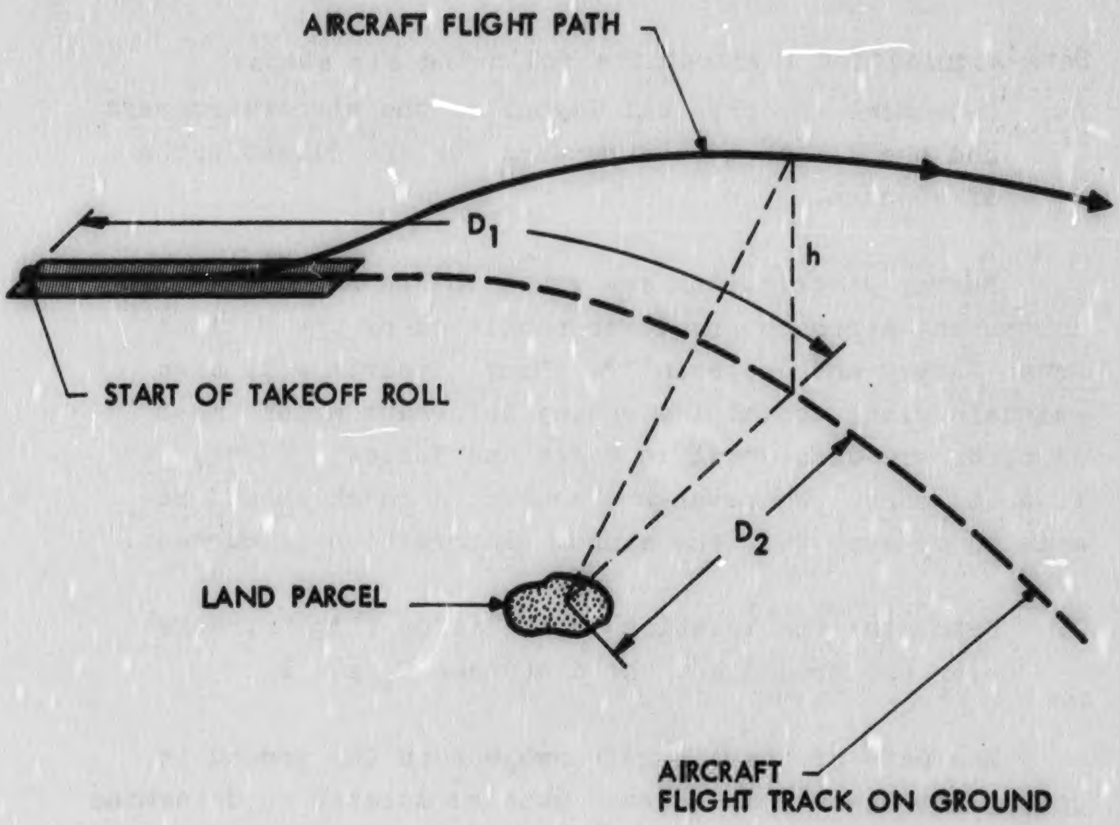


FIGURE 3. DEFINITION OF DISTANCES D_1 AND D_2 FOR AN AIRCRAFT TAKEOFF

curved, the distance D_1 must be measured along the arc of the curve. D_2 is the distance along the perpendicular drawn from the flight track to the desired position.

For landing, as shown in Figure 4, D_1 is the distance along the flight track from the landing threshold* to the perpendicular drawn from the flight track through the land parcel. D_2 is the distance along the perpendicular from the flight track to the ground position.

Figure 5 provides a form for tabulating the D_1 and D_2 distances. The maps and sketches which provide the basic track information from which the D_1 and D_2 distances are determined should accompany this form.

Unfortuantely, aircraft do not fly along flight tracks like cars along an expressway. The actual flight tracks flown tend to fan out from the nominal flight track as the aircraft get further from the airport. Locating the turning point of just one aircraft will not necessarily be representative of the mean flight track.

**The landing threshold identifies the beginning of the runway that is available and suitable for landings. For most runways the landing threshold coincides with the physical beginning of the runway. However, at some airports the landing threshold is displaced along the runway. This displaced threshold would be noted in the instrument approach procedure charts but will not be indicated on Coast and Geodetic Survey Maps.*

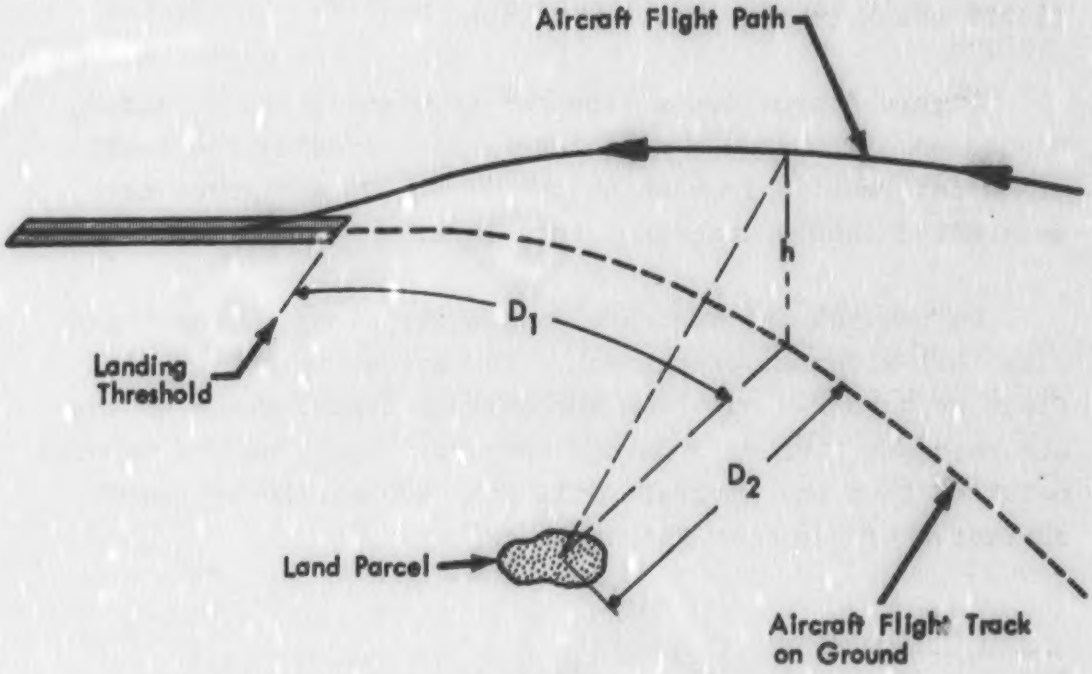


FIGURE 4. DEFINITION OF DISTANCES D_1 AND D_2 FOR AN AIRCRAFT APPROACH

Several sources may have to be contacted to obtain reliable track information. Often, the best source of information will be the FAA tower or airport operations personnel. The appropriate takeoff and approach charts from the Jeppesen Guide[5] may be of some help (these charts may be obtained individually from the publisher). Direct visual observation may be needed to resolve conflicting information, or to help determine the extent of variations in flight tracks for different aircraft.

3. Determine the types of aircraft producing the noise intrusions.

For convenience, aircraft are classified into different aircraft types determined on the basis of their noise characteristics and operational characteristics. Table 1 presents the aircraft classification to be used in this report. The table lists the general aircraft types with specific examples. The aircraft types are listed approximately in order of their noisiness. The aircraft range from the 4 engine turbofan aircraft such as the Boeing 707 and DC 8 series down to the smaller piston engine propeller aircraft such as the Cessna 180.

Most airports will handle operations of several types of aircraft. Start by determining the number of aircraft operations for each type of aircraft beginning with the top of the list in the table. Where the number of jet aircraft operations (transport and general aviation) exceed more than 5% of the total operations, you need not obtain detailed information for the propeller aircraft operations.

TABLE 1

NOISE CHART CODES ASSOCIATED WITH AIRCRAFT TYPES

RANKED BY APPROXIMATE NOISINESS

Aircraft Type	Aircraft Code	Typical Aircraft	Takeoff SEL at 15,000 ft. from Start of TO[1], dB	Landing SEL at 6,000 ft. from Threshold[2], dB
4-Engine HBPR turbofan	4-T-TFH	747	111.5	108.3
4-Engine LBPR turbofan	4-T-TFL	707, DC-8	110.9	106.4
4-Engine LBPR turbofan (quiet nacelle)	4-T-TFL(Q)	707(QN) DC-8(QN)	109.7	97.2
3-Engine LBPR turbofan	3-T-TFL	727	109.6	101.1
3-Engine LBPR turbofan (quiet nacelle)	3-T-TFL(Q)	727(QN)	109.3	96.1
4-Engine HBPR turbofan (quiet nacelle)	4-T-TFH(Q)	747(QN)	108.6	103.1
2-Engine Composite Business Jet (turbojet/turbofan)	2-G-TJ	Jetstar I, Learjet 23-25, Learjet 35-36, Jetstar II	104.9	101.3
2-Engine LBPR turbofan	2-T-TFL	737, DC-9	101.9	94.3
2-Engine LBPR turbofan	2-T-TFL(Q)	737(QN), DC-9(QN)	101.9	93.1
3-Engine HBPR turbofan	3-T-TFH	L-1011, DC-10	101.8	98.8
4-Engine propeller	4-T-PP	DC-4, DC-6	98.8	90.3
4-Engine turboprop	4-T-TP	Electra	97.8	92.1
2-Engine G.A.[3] turboprop	2-G-TP	Twin Otter, King Air, Turbo Commander	93.5	92.4
2-Engine G.A.[3] propeller (large)	2-G-LPP	DC-3	92.5	87.3
2-Engine G.A.[3] propeller (small)	2-G-SPP	Cessna 310-401	83.2	80.5
2-Engine G.A.[3] turbofan (small)	2-G-TFS	Cessna Citation	81.4	80.3
1-Engine G.A.[3] propeller	1-G-PP	Cessna 150-210, Piper Cher.140-235	81.8	72.9

[1] ATA (Air Transport Association) takeoff procedure at max. weight category

[2] 3° approach

[3] General aviation

4. Determine the mode of operations (Takeoff or landing) for the aircraft producing noise instrusions.

Noise produced during takeoff and landing may differ considerably. Similarly, the flight paths followed by aircraft in landing and takeoff may differ significantly. For those reasons the number of operations for each class of aircraft must be identified by mode. If a detailed analysis is being performed, takeoff operations must also be broken down by trip length (see Section V-A).

5. Determine the number of operations per daytime and per nighttime period.

The average number of operations per day should be determined for each aircraft class and mode of operations. For most purposes, the number of operations over a one year period should be used as the basis for determining the average number per day. For some detailed investigations you may wish to consider the number of operations occurring over a shorter period. For example, when pronounced changes in aircraft operations occur during different seasons of the year, you might wish to calculate separate day/night levels for the different seasons.

Determining the number of operations for each aircraft class and mode of operation may not be easy since detailed aircraft operational records are not usually available. The log of operations maintained by the FAA tower personnel will provide the yearly number of air carrier, air taxi, general aviation and military operations.* However, the FAA records do not identify the type of aircraft.

Sources of information for identifying transport aircraft are the Official Airline Guide** (OAG) and the flight schedules published by the individual airlines. Some airports also provide a schedule of aircraft arrivals and departures. And, do not neglect to check on freight operations.

Discussion with the airport operator and tower personnel will generally provide good estimates of the number of business jet and propeller aircraft operations.

The information as to number of operations obtained from different sources may be for differing time periods - for example, daily, monthly or yearly totals. For calculation purposes, this information should be corrected to a common basis - the average number of takeoffs and landings *per day*. The number of daily takeoffs and landings should then be entered on a form (Figure 5).

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* *For airports having FAA towers, this information is published in "FAA Air Traffic Activity", a publication issued by the FAA usually on both a calendar and a fiscal year basis.*

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AIRPORT ____________ FLIGHT TRACK ☐ MAP. ☐ OTHER

TRACK					
AIRCRAFT					
OPERATION					
N_D					
N_N					
D_1					
D_2					
CHART					
SEL					
K					
PARTIAL L_{DN}					

TOTAL L_{DN} ____________

FIGURE 5. L_{DN} DATA COLLECTION AND CALCULATION CHART

6. Determine the flight path utilization.

Track utilization is defined as the proportion of operations in each direction along the flight track. Takeoff direction along the runway may well reverse during different periods of the day or year due to changes in wind direction or traffic needs. Sometimes the same flight track will be used for aircraft departing and for aircraft landing.* In other cases, the flight track may differ for takeoff and landing operations. For example, the landing track may be straight into the runway while the takeoff may involve a turn after liftoff.

Accurate information on runway or flight track utilization is sometimes difficult to obtain. This information may be provided by the airport operator, FAA tower or traffic personnel. Where detailed records are not available, estimates of track utilization may be obtained by studying wind rose information (see reference 6).

Obtaining the above information completes the collection of data for the basic L_{dn} calculations. The information collected should be sufficient to complete the top seven rows of the data collection and calculation form (Figure 5).

At this point, it is important to check that the acquired information on numbers of takeoff or landings and

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Note that in this case although the same flight track is used, the distance D_1 will differ for takeoff and landing by the length of the runway.

path utilization are in the desired format. The values of N_D and N_N to be entered in Figure 5 are the number of takeoffs or approaches per day along the specified track. Thus, if you know the total number of takeoffs of aircraft type j per day for the airport, and the utilization of track k, then the number of takeoffs of aircraft j on track k is:

$$N(j,k) = \frac{N(j).\ U(j,k)}{100}$$

where $U(j,k)$ = Utilization of track k by aircraft j, in percent.

The traffic data may not be given in the desired format, and there are certain pitfalls that are easily fallen into. Check, for example, whether the distributions of landings or takeoffs on each track are given as a percentage of all operations on that track, as a percentage of landings or takeoffs at the airport, or as a percentage of all opeerations at the airport. At each stage in the calculations, it is most important to check that the total number of operations is correct.

In general, calculating the number of operations to two significant figures is sufficient, but do not ignore nighttime operations just because they may be an order of magnitude less than daytime operations. As explained earlier, the number of nighttime operations is multiplied by 10 in the calculations, hence nighttime operations, when they occur, will likely be significant.

7. Special takeoff or landing procedures.

When making a detailed noise assessment, additional operational information may need to be acquired.

(a) Special noise abatement takeoffs

The basic noise charts assume ATA (Air Transport Association) takeoff procedures for civil jet transport operations. Special noise abatement procedures involving reduction of engine thrust as specific altitudes may either be implemented at some airports or may be contemplated as part of a noise reduction program. Information on the procedures including the description of the procedures and the aircraft using the procedures should be collected. Section V discusses the usage of such information in detail.

(b) Special landing profiles

For basic calculations, assume a 3° glide slope for all turbojet aircraft and the larger propeller aircraft; for smaller propeller aircraft, assume a 4-1/2° glide slope. For other approach angles, see Section V-B. In some cases, a two-segment approach may be used, in which aircraft start their approach on a 6° glide slope and then transition to a 3° glide slope at 2 nautical miles from the landing threshold. These approaches have special noise charts associated with them; these are identified in Section III-B.

8. Data collection example (Example 1).

Two small parcels of land P and Q are the subject of an investigation of aircraft noise at Mythical Airport (see Figure 6). Distances from the runway and flight tracks are as shown, and the following operational data have been collected:

- Total daily operations at airport: 150*

- Distribution of landings or takeoffs on each track as percentage of all landings or takeoffs at airport

	27A	27B	09A
Landing	0%	10%	90%
Takeoff	30%	60%	10%

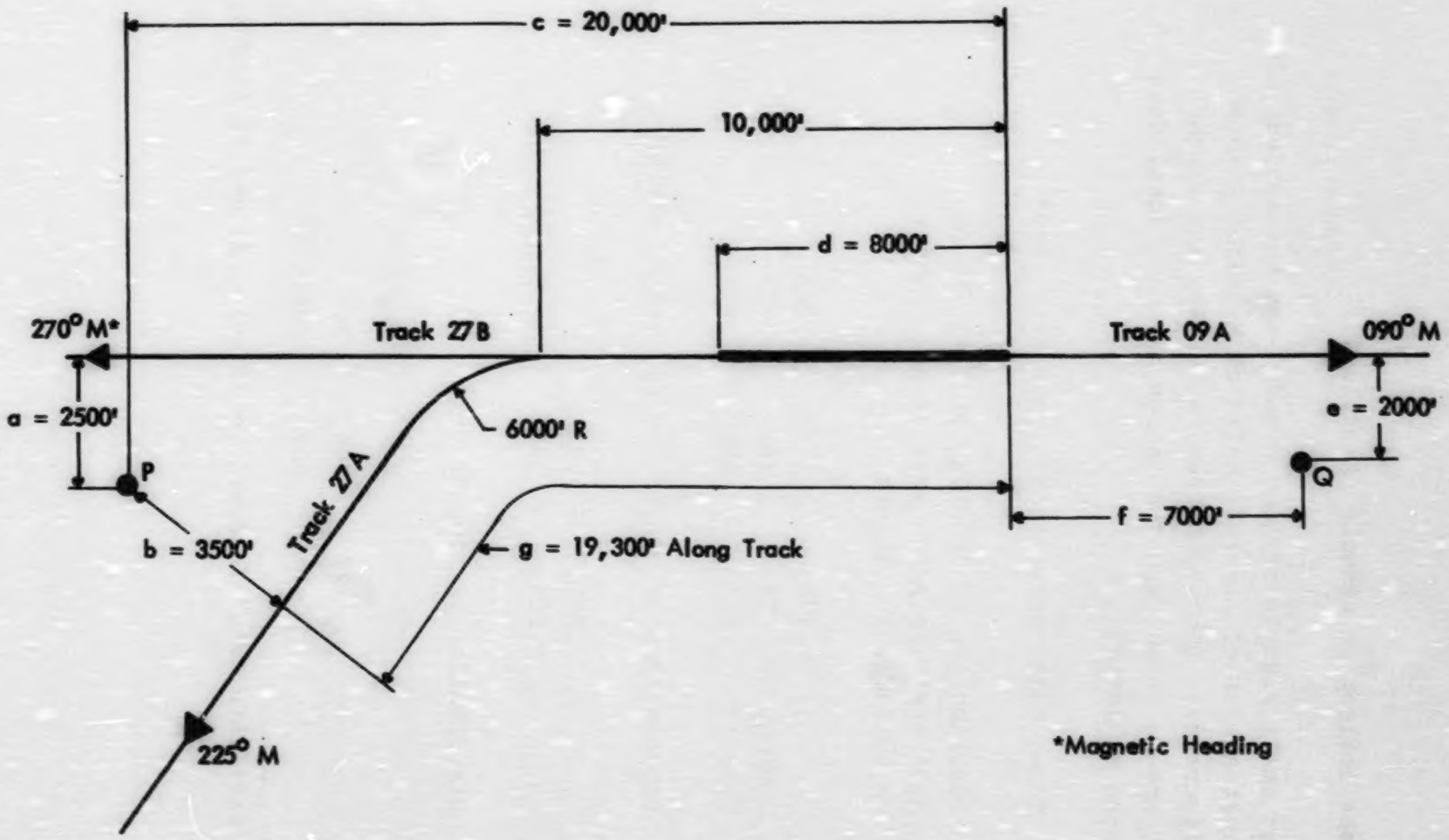
- Distribution of operations by type of aircraft:

B-727 - 70%
DC-9 - 30%

- Distribution by time of day:

	Day	Night
B-727	75%	25%
DC-9	80%	20%

**Note that this total is equal to 75 takeoffs and 75 landings.*



*Magnetic Heading

FIGURE 6. EXAMPLE: FLIGHT TRACKS AT MYTHICAL AIRPORT

The first step is to calculate the distance D_1 and D_2 for the points P and Q pertaining to each track. These distances are tabulated in Figure 7.

> Remember that D_1 does not have the same value for takeoffs and landings. For takeoffs, D_1 is measured along the track from the brake release point, which is the point when the aircraft starts its takeoff roll (i.e. the far end of the runway for aircraft coming towards you). For landings, D_1 is measured to the landing threshold which is usually the near end of the runway, except in the case of a displaced threshold.

The values of D_1 and D_2 can be measured directly off Figure 6, and accuracy to two significant figures is quite adequate. In this example, both types of aircraft conveniently start their turn after takeoff at the same point. More often, however, the flight instructions would call for a turn at a given altitude, and since aircraft have differing rates of climb, the turn would be initiated at different points.

The next step is to calculte the total number of operations at the airport broken down by type, i.e.

B-727	150 x 0.7 =	105
DC-9	150 x 0.3 =	45
	Total =	150

Break these numbers down into day and night operations:

	Day	Night	Total
B-727	105 x .75 = 79	105 x .25 = 26	105
DC-9	45 x .80 = 36	45 x .20 = 9	45
			150

These aircraft must be distributed on each flight track:

Track 27A

	Landing		Takeoff	
	Day	Night	Day	Night
B-727	0	0	12	3.9
DC-9	0	0	5.4	1.4

Track 27B

B-727	4.0	1.3	24	7.8
DC-9	1.8	0.5	11	2.7

Track 09A

B-727	36	12	4.0	1.3
DC-9	16	4.1	1.8	0.5

Check on total operations = 151.5
(the discrepancy here is due to rounding error)

The data has now been broken do[illegible]o that the L_{dn} collection and calculation chart can be completely filled in (Figure 7).

AIRPORT Mythical - Position Q FLIGHT TRACK ☐ MAP ☐ OTHER

TRACK	09 A	09 A	09 A	09 A	
AIRCRAFT	B-727	B-727	DC 9	DC 9	
OPERATION	T/O	Landing	T/O	Landing	
N_D	4.0	36	1.8	16	
N_N	1.3	12	0.5	4.1	
D_1	$\overset{(d+f)}{15{,}000}$	$\overset{(f)}{7000}$	$\overset{(d+f)}{15{,}000}$	$\overset{(f)}{7000}$	
D_2	$\overset{(e)}{2000}$	$\overset{(e)}{2000}$	$\overset{(e)}{2000}$	$\overset{(e)}{2000}$	
CHART					
SEL					
K					
PARTIAL L_{DN}					

TOTAL L_{DN}

FIGURE 7 (a). L_{DN} DATA COLLECTION AND CALCULATION CHART
EXAMPLE 1

AIRPORT Mythical - Position P FLIGHT TRACK ☐ MAP ☐ OTHER

TRACK	27 B	27 B	27 B	27 B	
AIRCRAFT	B-727	B-727	DC-9	DC-9	
OPERATION	T/O	Landing	T/O	Landing	
N_D	24	1.3	11	1.8	
N_N	7.8	0.5	2.7	0.5	
D_1	(c) 20,000	(c-d) 12,000	(c) 20,000	(c-d) 12,000	
D_2	(a) 2500	(a) 2500	(a) 2500	(a) 2500	
CHART					
SEL					
K					
PARTIAL L_{DN}					

TOTAL L_{DN}

FIGURE 7 (b). L_{DN} DATA COLLECTION AND CALCULATION CHART EXAMPLE 1

AIRPORT Mythical - Position P FLIGHT TRACK ☐ MAP ☐ OTHER

TRACK	27 A	27 A	27 A	27 A	
AIRCRAFT	B-727	B-727	B-727	B-727	
OPERATION	T/O	LANDING	T/O	LANDING	
N_D	12	0	5.4	0	
N_N	3.9	0	1.4	0	
D_1	(b) 3500	-	(b) 3500	-	
D_2	(g) 19,300	-	(g) 19,300	-	
CHART					
SEL					
K					
PARTIAL L_{DN}					

TOTAL L_{DN}

FIGURE 7 (c). L_{DN} DATA COLLECTION AND CALCULATION CHART EXAMPLE 1

B. Determine the SEL for each Contributing Aircraft Noise Event

1. Check the Distances D_1 and D_2

The knowledge of D_1 and of the aircraft takeoff and landing profile determines height of the aircraft above ground (see Figures 3 & 4) as it passes near the ground position. *You do not have to calculate the height. It is automatically calculated and taken into account in the noise charts.*

2. Select the Proper Noise Chart

All the information has now been assembled for selection of the proper noise charts. The selection of the noise chart is determined by:

- Aircraft type (in accordance with Table 1)
- Mode of operation (takeoff or landing)
- Distance D_1

The noise charts are listed in Appendix A. Each noise chart covers a range of the distance D_1, and several charts may be needed to cover the entire range of D_1 values for each aircraft and mode of operation.

Noise charts are identified according to the code listed below. This shows an example of the coding used by the charts for the basic L_{dn} calculation:

```
 4 - T - TFL(Q) - TO(I) - N - 1
(1) (2)   (3)      (4)    (5) (6)
```

(1) The first number identifies the number of engines in the aircraft.

(2) This letter signifies either transport aircraft (T) or general aviation aircraft (G).

(3) The next group of letters identifies the type of engine, as follows:

TJ - Turbojet
TFL - Low bypass ratio turbofan
TFH - High bypass ratio turbofan
TP - Turboprop
PP - Propeller driven by reciprocating engine
LPP - Propeller driven by reciprocating engine (large)
SPP - Propeller driven by reciprocating engine (small)
TFS - Turbofan (small)

The appendix (Q) signifies a quiet nacelle engine.

(4) The mode of operation is identified with a TO for takeoff and L for landing. (I), (II) or (III) refers to the takeoff profiles associated with different flight trip lengths when a detailed noise analysis is being performed (see Section V-A). If the trip length is not known, use profile (II).

(5) This group of letters refers to the special procedure that may be used. The interpretation of the coding is as follows:

- S Standard takeoff or landing
- N Northwest Orient Airlines noise abatement takeoff
- F FAR Part 36 takeoff
- T Two-segment approach

(6) The last number of the code identifies the number in the set. The graphs within a set encompass different ranges of the distance D_1. For the turbojet and turbofan aircraft there are usually three graphs in a takeoff set and two graphs in a landing set. For the propeller aircraft there are two graphs in a takeoff set and one graph in a landing set.

For a given type of aircraft, look up the chart code in Table 1 (page26) which will give the first three groups of the code. If the operation is a takeoff and stage lengths are not known, use the chart with TO (II) in the code (if the stage lengths are known, see Chapter V). Check also whether the airport uses standard or special takeoff and landing procedures. Finally, look through the subset of charts for the chart that shows the appropriate range of D_1. The desired SEL value is determined by first establishing the D_2 distance along the horizontal axis. A perpendicular is then drawn on the graph to intersect the proper D_1 value. The appropriate D_1 distance is established by interpolation between the bracketing D_1 curves. From this intersection, a line is drawn horizontally to intersect the vertical. The point of intersection gives the proper SEL value.

C. Complete the partial L_{dn} value

1. Calculate the correction for the number of operations.

The SEL value for a given type of aircraft and mode of operation must now be adjusted for the number of times this particular type of aircraft flies along this track. This adjustment is made by subtracting the variable K which is dependent on the number and distribution of day and night flights. The equation* for K is $49.4 - 10 \log (N_D + 10N_N)$ and its solution is graphed in Figure 8. In Figure 8, find the nearest whole number value of K for the intersection of the number of daytime (N_D) and nighttime (N_N) operations for the given type of aircraft, mode of operation and track.

2. Calculate the partial L_{dn} value.

The partial L_{dn} value [$L_{dn}(i,j)$] is simply the arithmetic difference of the SEL value found above and the appropriate K value:

$$L_{dn}(i,j) = SEL(i,j) - K(i,j)$$

The process is now completed for obtaining an $L_{dn}(i,j)$

**See Equation 2, page 7*

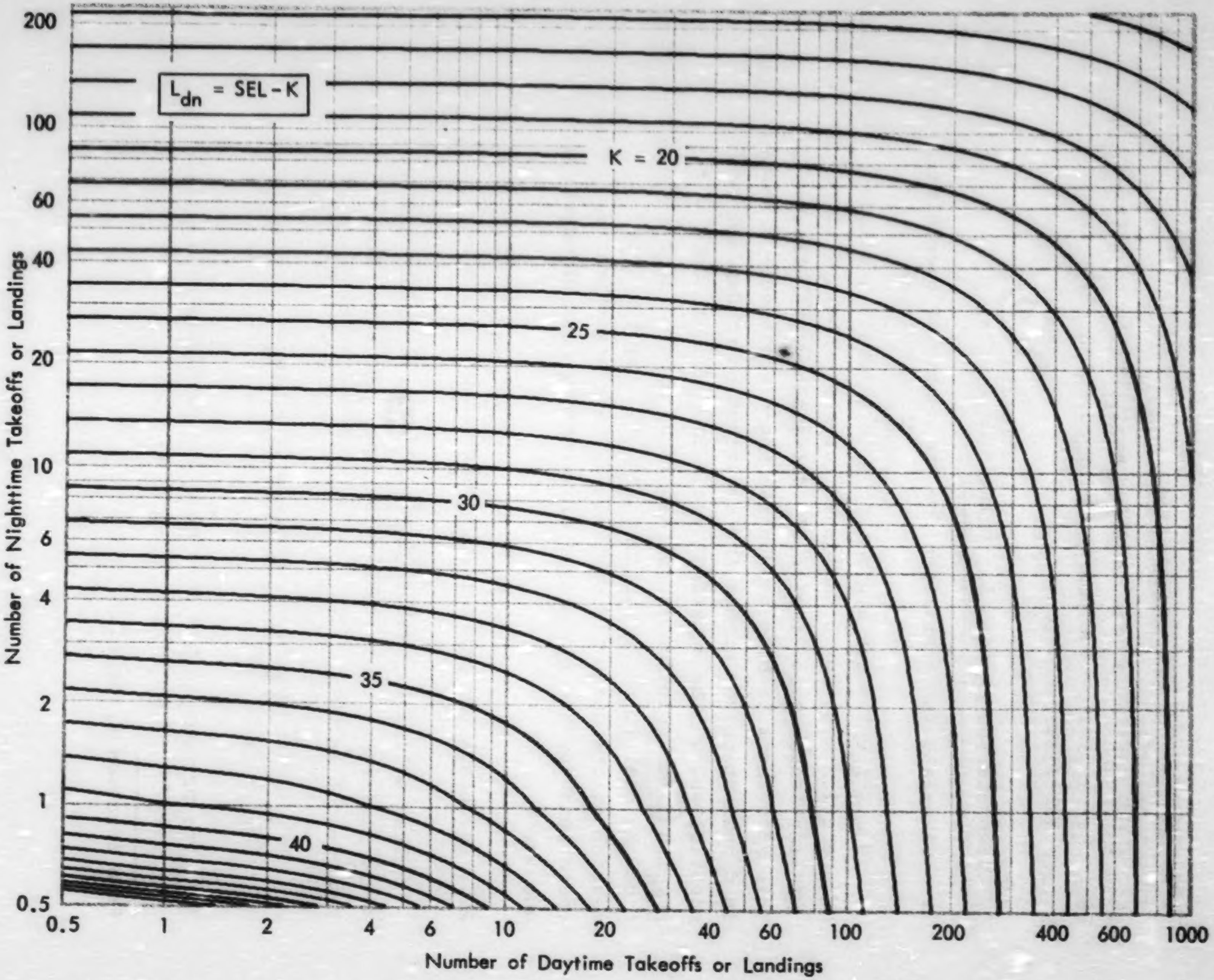


FIGURE 8. CHART FOR DETERMINING THE ADJUSTMENT "K" FOR NUMBER OF AIRCRAFT OPERATIONS DURING DAY AND NIGHT PERIODS

value for class of aircraft and mode of aircraft operation j. Repeat for each major aircraft type and mode of operation. Repetition will result in a set of $L_{dn}(i,j)$ values. The total aircraft noise environment is then the summation of these partial L_{dn} values.

D. Add the partial L_{dn} values to obtain the total L_{dn} for aircraft operations

Since the partial L_{dn} values are expressed in decibels, they cannot be added together by ordinary arithmetic. Instead "decibel addition" is involved.* A chart for adding sound levels quite accurately by "decibel addition" is given in Figure 9. This chart can be used to an accuracy of 0.1 dB, but most applications will not require (nor justify) this degree of precision. A more practical addition procedure for quickly estimating the sum of two or more decibel levels is given in the top of Table 2. The use of this table will yield a sum that has an accuracy within 1 dB. An accuracy within 1/2 dB can be obtained

---

**Remember that the decibel scale is logarithmic and expresses the ratio of two quantities related to power (with one quantity being a reference value). When* L_{dn} *values to be combined are ("decibel addition"), the values are combined on an energy basis. The rigorous procedure for doing this is to convert the decibel numbers to relative powers, to add the powers and then convert back to the corresponding decibels. The availability of scientific calculators that have* 10^x *and* $\log_{10}x$ *functions makes decibel addition very easy and precise.*

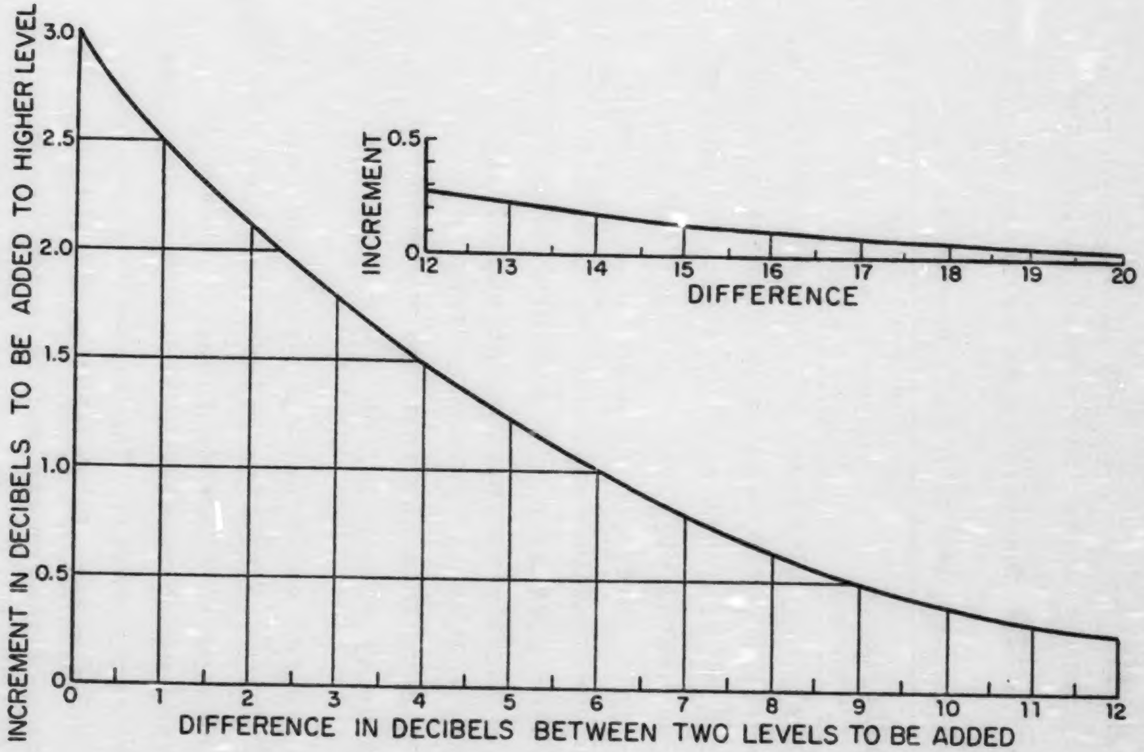


FIGURE 9. CHART FOR COMBINING SOUND LEVELS BY "DECIBEL ADDITION"

TABLE 2

RULES FOR COMBINING SOUND LEVELS BY "DECIBEL ADDITION"

A. For noise levels know or desired to an accuracy of ± 1 decibel:

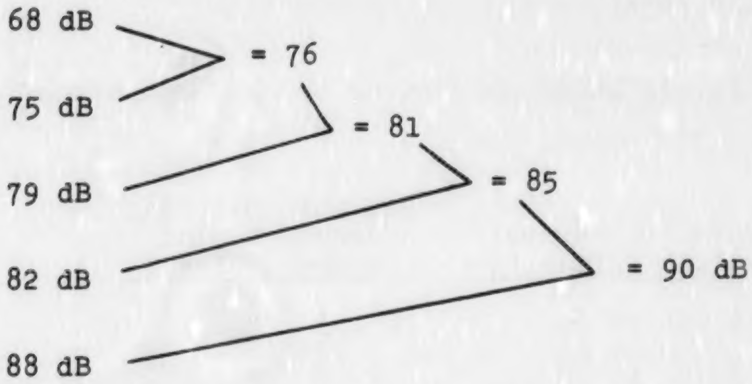
When two decibel values differ by	Add the following amount to the higher value
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 9 dB	1 dB
10 dB or more	0 dB

B. For noise levels known or desired to an accouracy of ± ½ decibel:

When two decibel values differ by	Add the following amount to the higher value
0 or ½ dB	3 dB
1 or 1½ dB	2½ dB
2 to 3 dB	2 dB
3½ to 4½ dB	1½ dB
5 to 7 dB	1 dB
7½ to 12 dB	½ dB
13 dB or more	0 dB

(For greater accuracy, refer to chart in Figure 5) by using the lower half of Table 2. This degree of accuracy in comparing L_{dn} values will generally be adequate for most calculations.

When a number of partial L_{dn} values are to be added, using Table 2 or Figure 9, they should be added two at a time, starting with the lower valued levels and continuing the addition procedure of two at a time until only one value remains. To illustrate, suppose it is desired to add the following five levels, using the summation procedure of the upper portion of Table 2:



Addition of the partial L_{dn} values completes the procedure. Table 3 summarizes the basic calculation steps that have been described.

E. Examples

The following two examples illustrate the procedure, the first for a single aircraft operation and the second for multiple aircraft operations. Calculations for these examples are given in Figure 10.

Example 2 -

Consider a site exposed to noise from takeoffs of 4-engine LBPR turbofan aircraft with the aircraft departing along a curved flight path essentially as shown in Figure 3 (page22). There are twelve operations during daytime hours (between 7 am and 10 pm) and two nighttime operations (between 10 pm and 7 am). The standard ATA takeoff procedure is used but the stage lengths are unknown.

Measurement of the flight track on a map shows that the distance D_1 is 22,000 feet and the distance D_2 is 1000 feet.

Entering the takeoff chart 4-T-TFL-TO(II)-S-3 which covers D_1 distances from 18,000 to 190,000 feet and using distance D_2 value of 1000 feet, an SEL value of 101.3 dB is obtained. Note that a curve for D_1 equal to 22,000 feet is located two-fifths of the distance between the D_1 curves for 20,000 and 25,000 feet.

The interpolation here can be done by inspection or by calculation:
At D_2 = 1000 ft.

D_1	SEL
20,000	102
25,000	100.2

Thus, the SEL for a D_1 of 22,000 ft. is

$$102 + \frac{22{,}000-20{,}000}{25{,}000-20{,}000} \cdot (1.8)$$

$$= 102 - \frac{2}{5}(1.8) = 102 - 0.7 = 101.3$$

From Figure 8, the "K" value for N_D equal to 12 and N_N equal to 2 is 34.5 dB. Therefore, as shown in column 1 of Figure 10, the L_{dn} is 66.8 dB.

Example 3 -

Consider the same site as in Example 2. The airport is considering a change in aircraft departure paths, such that a large proportion of aircraft would make a "straight-out" departure as sketched in Figure 11. The total number of departures is unchanged. What will be the change in noise exposure at the site as a result of this change of operations? The needed operational information is tabulated in columns 2 and 3 of Figure 10. Eight daytime flights have been changed from flight path A to flight path B. The two night operations have been split between the two paths.

The distance D_1 and D_2 are tabulated in Figure 10. The SEL values from 4-T-TFL-TO(I)-S-3 are also tabulated. The new flight path results in an SEL that is 2.3 dB lower than that for flight path A.

AIRPORT ______________

FLIGHT TRACK ☐ MAP ☐ OTHER

	(1)	(2)	(3)		
TRACK	A	A	B		
AIRCRAFT	B-707	B-707	B-707		
OPERATION	T/O	T/O	T/O		
N_D	12	4	8		
N_N	2	1	1		
D_1	22,000	22,000	20,000		
D_2	1000	1000	2000		
CHART	4-T-TFL-TO(II)-S-3	4-T-TFL.-TO(II)-S-3	4-T-TFL-TO(II)-S-3		
SEL	101.3	101.3	99		
K	34.5	38	37		
PARTIAL L_{DN}	66.8	63.3	62.0		

$$\underbrace{\qquad\qquad\qquad\qquad}_{65.8 \text{ (Example 3)}}$$

TOTAL L_{DN} 65.8 (Example 3)

FIGURE 10. L_{DN} DATA COLLECTION AND CALCULATION CHART EXAMPLES 2 & 3

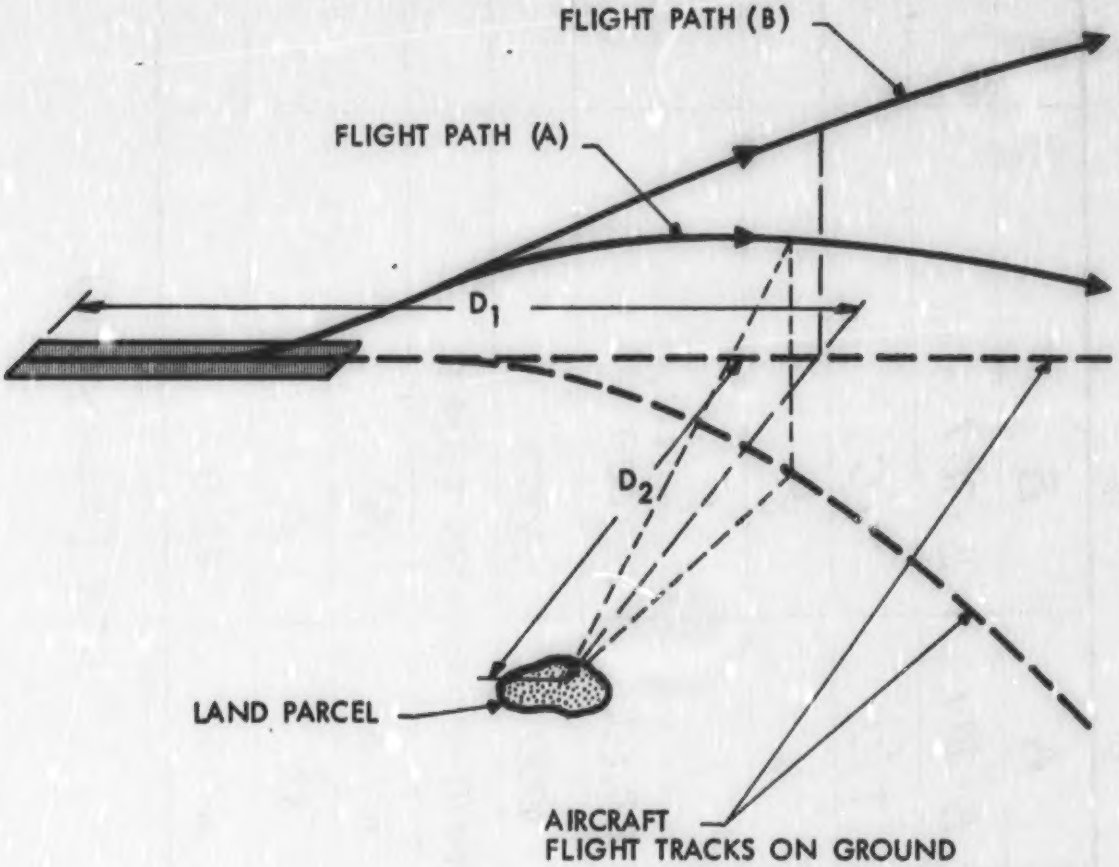


FIGURE 11. FLIGHT PATHS AND DISTANCES FOR EXAMPLE 3

Subtracting the "K" values obtained from Figure 10 results in partial L_{dn} values of 63.3 dB and 62.0 dB. Adding the two partial L_{dn} values by means of Table 2-B results in a total L_{dn} of 65.8 dB as shown below.

63.3 - 62.0 = 1.3 dB. By Table 2-B,
2.5 dB should then be added to 63.3 dB
63.3 + 2.5 = 65.8 dB
(More precise calculations yield 65.7 dB.)

Thus, the change in flight paths has resulted in a decrease in noise exposure at the site by 1 dB.

The procedures involved in this section are summarized in Table 3.

TABLE 3. DAY-NIGHT LEVEL CALCULATION SUMMARY

1. Obtain operational input information:
   - Aircraft type
   - Mode of operations: takeoff or landing
   - Number of operations for:
     - Daytime (N_D)
     - Nighttime (N_N)
   - Flight track location in the ground
2. From a flight track map, obtain distances D_1 and D_2 (see Figure 2)
3. Select proper aircraft noise chart, based on:
   - Aircraft type
   - Mode of operation
   - Distance D_1
4. From the noise chart, determine the aircraft sound exposure level (SEL) by entering the chart using distances D_1 and D_2.
5. Obtain the "K" value for number of operations from Figure 8, using N_D and N_N.
6. Subtrack K from SEL to obtain the partial L_{dn}.
7. Repeat Steps 1 through 6 for each separate aircraft type and mode of operations that would contribute to the noise exposure at the land parcel.
   Thus, for each aircraft type i, and mode of operation j, one will obtain a corresponding $L_{dn}(i,j)$.
8. "Add" the $L_{dn}(i,j)$ values using Table 2 or Figure 5 to obtain the total aircraft L_{dn}.

SECTION IV

METHOD FOR DETERMINING APPROXIMATE L_{dn} CONTOURS FOR A SINGLE FLIGHT PATH

A. Calculate the Equivalent SEL Value

The procedures given in this manual enable you to calculate the L_{dn} value at a given ground position. They do not provide an efficient way to determine contours (lines of equal L_{dn} values) which may cover quite large land areas. As noted earlier, standard computer programs are available for generating L_{dn} contours.

For some planning purposes, it may be desirable to make an estimate of contour size and dimensions for a specific flight path. To accomplish this limited aim, this section outlines a way of determing the approximate size and area of a specified L_{dn} contour. The basic approach lies in determining the *dominant mode* of operation (takeoff or landing), the *most significant aircraft* in terms of noise contribution for that path, and then calculating an *equivalent SEL* corresponding to the desired L_{dn} values for which contours are needed. Once the equivalent SEL value is determined, the approximate contours can be determined, as outlined in Section IV-B.

This procedure has several limitations. L_{dn} contours may be influenced by both takeoff and landing operations but in this method, only the dominant mode of operation is considered. Another limitation is that in many locations, the L_{dn} values are influenced by contributions from more than one flight path; this procedure is based upon noise from aircraft *on only one flight path.*

The method for calculating the equivalent SEL value is described in the following seven steps:

1. Identify the aircraft types and number of takeoffs and landings per day for the *three "noisiest" classes* of aircraft. In ranking the aircraft in terms of their contributions to the total noise environment, use the ranking of aircraft given in Table 1*.

If takeoff operations comprise 40% or more of the total operations, omit calculations for aircraft on approach. If takeoff operations comprise less than 30% of the operations, neglect the takeoff operations. Where takeoffs range between 30% and 39% carry out calculations for both takeoff and landing aircraft.

2. List the three classes of aircraft identified in Step 1 in the form given in Figure 5 together with the number of day and night takeoffs or landings for each aircraft. Also, list the appropriate takeoff or landing SEL values from Table 1 for each aircraft. This value is identified as the reference SEL value (SEL_R) for that aircraft and mode of operation.

**Table 1 lists the typical noise levels at a distance approximately 15,000 feet from start of takeoff or 6,000 from threshold on landing threshold. The relative ranking of contributions may well change for different positions hence the listing in Table I is to be used for the purposes of this analysis only.*

3. Determine from Figure 8 the adjustment factor "K" for the number of day and night operations and list on Figure 5.

4. For each aircraft class, subtract the K values from the partial day/night levels.

$$(L_{dn})_R = SEL_R - K \qquad \ldots . \ (4.1)$$

5. Add the partial L_{dn} values as described in Section III-C to obtain the reference L_{dn} value for takeoffs and/or for landings. In cases where both landing and approach L_{dn} values have been calculated (see Step 1), compare the landing and takeoff values. If the landing value exceeds the takeoff L_{dn} value *by more than 3 dB* neglect the takeoff value in future calculations. If this is not the case, neglect the landing values in further calculations.

This assessment results in selection of the *dominant mode of aircraft operation* and establishes the reference L_{dn} value.

6. Identify the *dominant aircraft*, which is the aircraft that has the *highest partial* L_{dn} value for the dominant mode of operation.

7. Obtain the *equivalent SEL*, SEL_E, for the reference L_{dn} value. The equivalent SEL for the dominant aircraft is calculated as follows:

$$SEL_E = [L_{dn} - (L_{dn})_R] + SEL_R \qquad \ldots . \ (4.2)$$

where L_{dn} is the level whose contour you wish to calculate

$(L_{dn})_R$ is the reference value of L_{dn}

SEL_R is the reference value for the dominant aircraft

The SEL_E contour size and shape is approximately the same as the reference L_{dn} contour. The SEL_E is then used in Section IV-B to calculate the size and area of the L_{dnR} contour.

Example 4(a) You want to determine the approximate size and area for the L_{dn} = 60 contour for operations along the track 27B at Mythical Airport (see Figure 6); ATA takeoffs are used, but stage lengths are unknown. The breakdown of operations on an average daily basis along this track is now as follows:

Aircraft Type	Average Daily Landings		Average Daily Takeoffs	
	N_D	N_N	N_D	N_N
Boeing 747	3	1	10	3
Boeing 707	5	2	14	6
DC-9	7	2	20	5
Convair 440	5	1	16	3
Twin Otter	3	0	9	0

Looking at the ranking of Table I, it can be seen that the Convair 440 and Twin Otter can be eliminated from further consideration, since only the three noisiest classes of aircraft are to be considered. Looking, therefore, at the 747, 707 and DC-9, it can be seen that there are a total of 58 takeoffs and 20 landings. Takeoffs comprise more then

40% of all operations, so landings need not be considered. Write the values of N_D and N_N for each aircraft type on the Data Collection Chart (Figure 12) and calculate the values of K. Using the reference SEL values (SEL_R), calculate the partial L_{dn} values at the reference distance using SEL_R values from Table I, then calculate the reference L_{dn} by addition of the partial L_{dn} values. This results in a reference L_{dn} of 79.7. Finally, calculate the equivalent SEL using equation (4.2) so that

$$\begin{aligned} SEL_E &= (60 - 79.7) + 107.5 \\ &= 87.8 \end{aligned}$$

This value of SEL_E is used in the next section to calculate the shape for the L_{dn} = 60 contour (in Example 6).

B. Determine the Approximate Size of an SEL Contour

The procedure outlined in this subsection provides an approximate method of determining the width, length and area of an SEL contour for a specific aircraft operation (takeoff or landing) or of determining an L_{dn} contour using an equivalent SEL value (SEL_E). The procedure somewhat overestimates the size of the actual contour since it considers only air-to-ground noise propagation and neglects the increased attenuation due to ground-to-ground propagation which occurs when the aircraft is at a low elevation angle with respect to the listener.*

**The increased attenuation of noise for ground-to-ground propagation will mainly reduce the size of the contour while the aircraft is on the ground during takeoff roll.*

AIRPORT ____________ FLIGHT TRACK ☐ MAP ☐ OTHER

TRACK	27 B	27 B	27 B		
AIRCRAFT	B-747	B - 707	DC-9		
OPERATION	T/O	T/O	T/O		
N_D	10	14	20		
N_N	3	6	5		
D_1					
D_2					
CHART		4-T-TFL-TO(II)-5			
SEL_R	109	107.5	102		
K	33.3	30.8	31		
PARTIAL L_{DN}	75.7	76.7	71		

TOTAL L_{DN} 79.7

FIGURE 12. L_{DN} DATA COLLECTION AND CALCULATION CHART
EXAMPLES 4 & 6

1. Select the proper noise charts for the given aircraft and mode of operation (if calculating an L_{dn} contour, use the dominant aircraft and mode of operation). The set of curves can be identified as described in Section III-B.

2. Determine the approximate *contour closure distance.* The contour closure distance is the distance (from start of takeoff roll or from the landing threshold) at which the desired SEL value is attained *along the flight track.* This distance is identified as A in Figure 13.

The closure distance can be determined from the noise charts by finding the distance D, along the *left vertical axis* for the desired SEL value. (Note that since the closure distance is measured along the flight track, D_2 is zero). Interpolate between the D_1 curves to find the desired D_1 value, and identify this distance as A.

3. To find the maximum width of the SEL contour, determine the *maximum* value of D_2 for any value of D_1. To do this, draw a horizontal line on the chart(s) at the specified equivalent SEL value. Find the intersection with a D_1 curve that occurs farthest to the *right of the chart.* Read off D_2 on the horizontal axis corresponding to this intersection, and denote this as B. Where there is more than one chart to a takeoff or landing set, as will usually be the case, one should repeat this procedure for each chart, and take the largest value of D_2 as B*.

**As indicated in Figure 13, this procedure will result in determining B_1 the maximum width of the contour. At distances closer to the runway the noise contour may be narrower than those calculated from the above method because of the influence of ground-to-ground propagation.*

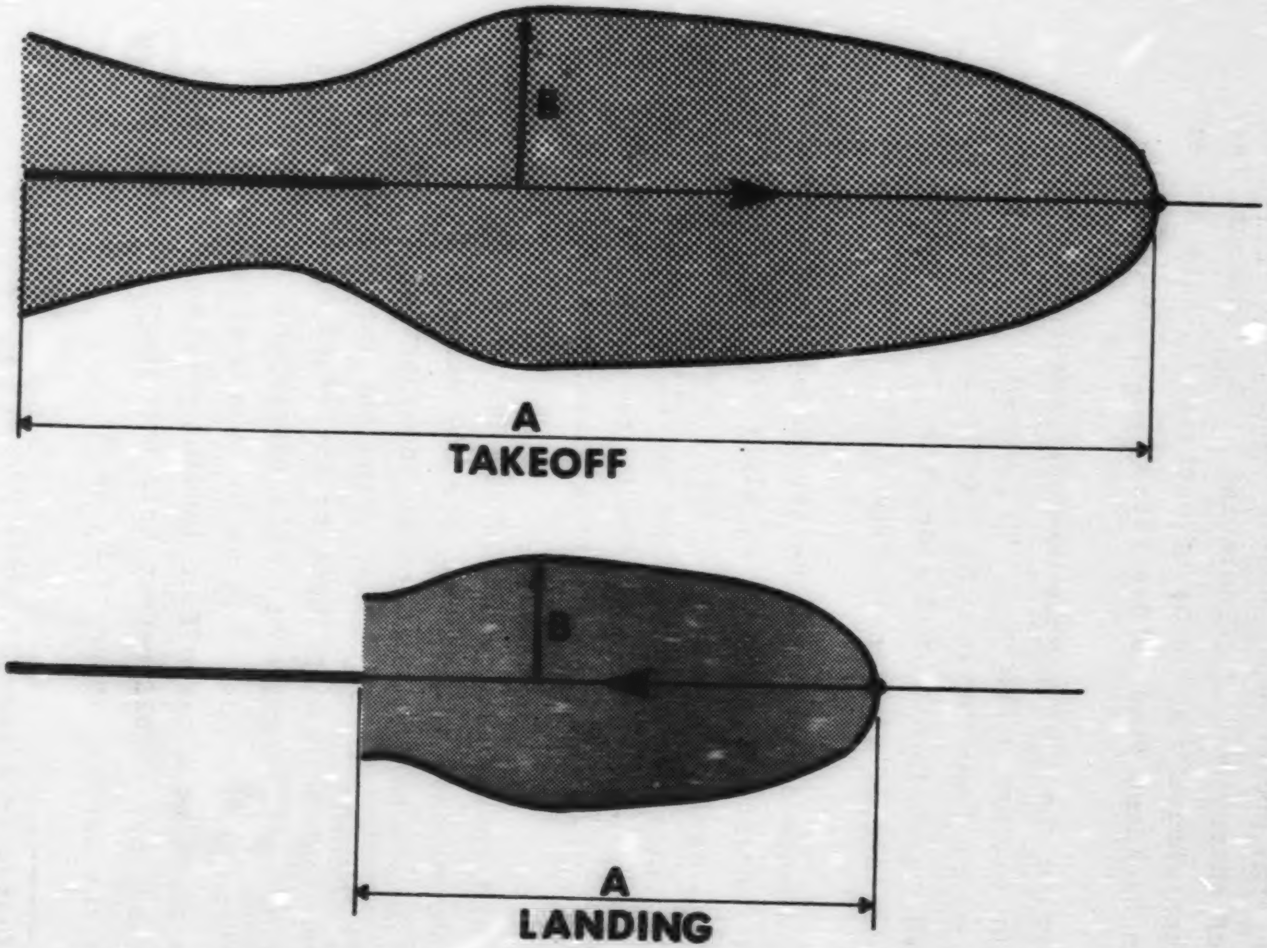


FIGURE 13. CONTOUR CLOSURE DISTANCE A

4. Calculate the approximate area of the contour. The approximate area of the contour is found from the following expression:

$$\text{Area} = \frac{\pi}{2} \times A \times B = 1.57 \times A \times B \quad .... \ (4.3)$$

This expression approximates the contour as a section of an ellipse. This area is greater than the actual contour size because the ground-to-ground transmission of sound is neglected.

Example 5 -

You wish to find the approximate area impacted by noise levels of 107 SEL and above as a result of standard takeoffs of 4 engine LBPR turbofan aircraft (707/DC-8). First, go to the approximate set of noise charts (4 - T - TFL - TO(II) - S - 1, 2, 3).

Figure 14, a copy of the second chart of this subset, shows that when D_2 is zero (i.e. looking along the vertical axis) an SEL of 107 occurs for a value of $D_1 \approx 15{,}000$ ft. Now moving horizontally along the line for SEL = 107, it can be seen that the largest value of D_2 is about 1350 ft. (This occurs for $D_1 = 8000$, but there is no need to record this.) Check all the charts in the set to see that this is, in fact, the largest value of D_2.

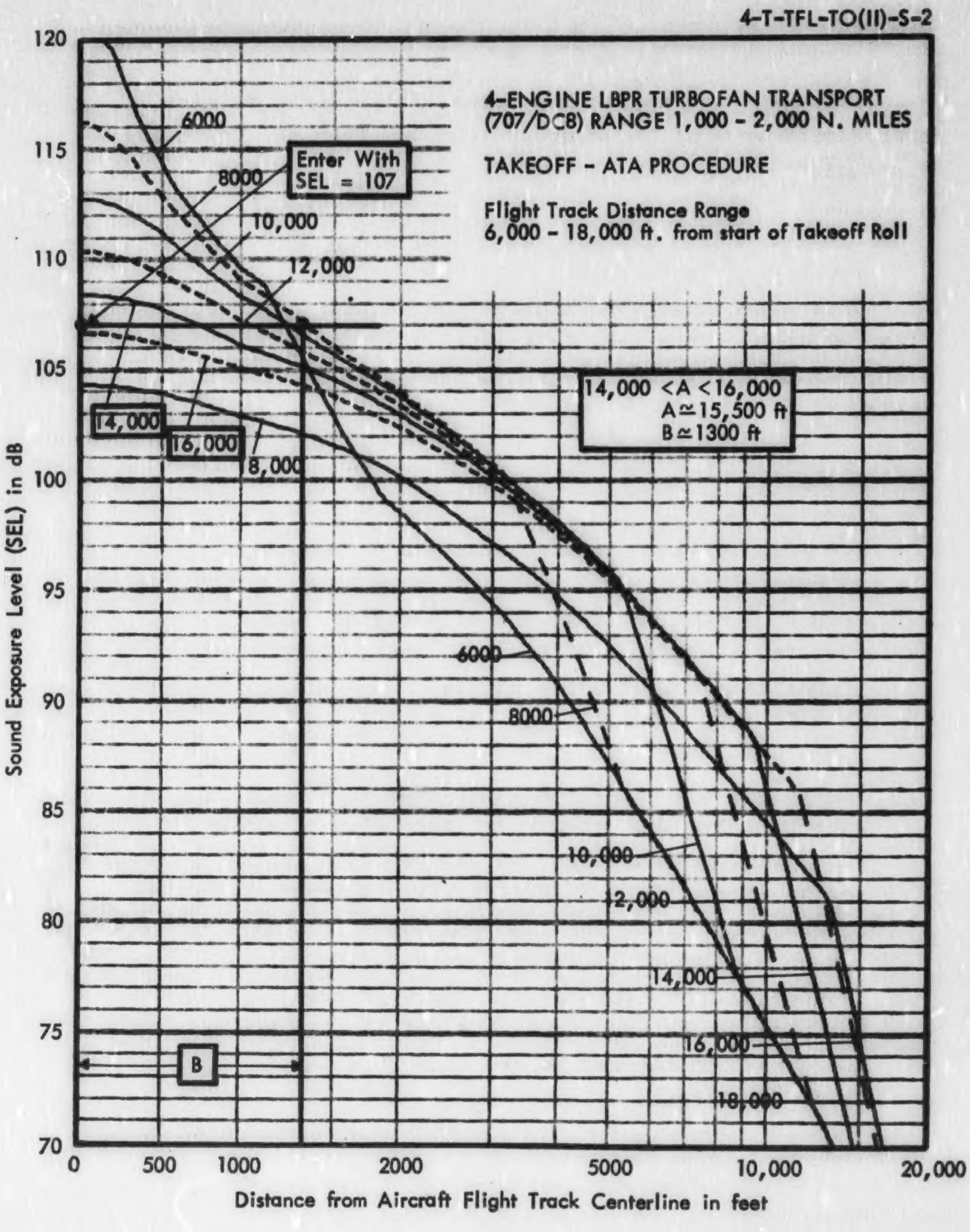


FIGURE 14. DETERMINING A AND B FOR CONTOUR AREA CALCULATIONS - EXAMPLE 5

Thus A = 15,500 ft.

B = 1,350 ft.

Area Impacted = 1.57 x 15,500 x 1,350

= 32.9×10^6 ft.^{2}

Example 6 -

This is the continuation of Example 4 in which an SEL value of 87.8 was obtained as equivalent to an L_{dn} value of 60. Turn to the takeoff noise charts for the dominant aircraft (4-T-TFL-TO(II)-S); the third chart of the series shows a contour closure distance, D_1, along the y axis of 90,000 ft. The maximum width, shown on the second chart in the series is 10,000 ft. This results in a contour area of 14×10^8 ft.^{2}

SECTION V

ADDITIONAL PROCEDURES FOR DETAILED NOISE ASSESSMENT OR NON-STANDARD FLIGHT PROFILES

A. Use of Special Charts for Differing Takeoff Weights

The gradient of the takeoff flight path affects the noise impact on the ground, and this gradient depends upon the takeoff weights of the aircraft. The takeoff weight depends on the amount of fuel carried, which in turn depends on the stage length of the particular flight.

For detailed noise calculations, takeoffs for each class of medium or long range aircraft should be further broken down by stage length for that trip. The categories of stage length depend on the actual type of aircraft and are shown in Table 4. The data collection form should be completed in the format as shown in Figure 15. The noise chart should then be selected that has the same Roman numeral in the fourth code group as the stage length category code.

B. Adjustment for Non-Standard Approach Glide Slope Angles

The approach noise charts for a jet aircraft given in this handbook assumes a 3° glide slope, and although this glide slope is found at many airports some exceptions may occur. This sub-section provides a method for adjusting the noise charts to predict SEL values for other glide slopes.

Besides a change in flight geometry which results in a change in the height of the aircraft at a given position

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TABLE 4

STAGE LENGTHS ASSOCIATED WITH TAKEOFF CATEGORIES

		Stage Length	
Aircraft Code	Category I	Category II	Category III
4-T-TFL	0-1000	1000-2000	> 2000
3-T-TFL	0-500	> 500	
2-T-TFL	0-500	> 500	
4-T-TFH	0-1000	1000-2000	> 2000
3-T-TFH	0-1000	1000-2000	> 2000
4-T-TP		ALL	
4-T-PP		ALL	
2-G-TJ		ALL	
2-G-TFS		ALL	
2-G-TP		ALL	
2-G-LPP		ALL	
2-G-SPP		ALL	
1-G-PP		ALL	

AIRPORT ________________ FLIGHT TRACK ☐ MAP ☐ OTHER

TRACK	27 B	27 B	27 B		
AIRCRAFT	B-747	B-747	B-747		
OPERATION	T.O. /Cat. I	T.O./Cat. II	T.O./Cat. III		
N_D	15	27	13		
N_N	2	5	3		
D_1					
D_2					
CHART	4-T-TFH-TO(I)	4-T-TFH-TO(II)	4-T-TFH-TO(III)		
SEL					
K					
PARTIAL L_{DN}					

TOTAL L_{DN}

FIGURE 15. L_{DN} DATA COLLECTION FOR DIFFERING TAKEOFF CATEGORIES under the flight path, a change in glide slope also may involve changes in air speed and engine thrust which also produce changes in the SEL values. The method described provides adjustments for the geometric changes but does not provide adjustments for air speed and engine thrust changes that may accompany the change in glide slope. For minor changes in glide angle, the air speed and thrust changes are likely to be quite small. For large angle changes, thrust and air speed changes may affect the noise levels appreciably.

Given a glide slope of x° and a position along a perpendicular to the flight path at a distance D_1 (x), the adjustment to the noise charts consists of finding the equivalent D_1 [$(D_1)_E$] for a 3° glide slope that has the same height (as illustrated in Figure 16). For glide slopes greater than 3 degrees, the equivalent distance will be larger distance than the actual D_1 (x); for glide slopes less than 3°, the $(D_1)_E$ will be less.

Figure 17 provides a simple nomograph for finding the equivalent D_1 distance to be used in the noise charts for glide slopes ranging from 2.5 to 7°. This nomograph simply solves the following equation.

$$(D_1)_E = D_1 \frac{\tan x^\circ}{\tan 3^\circ} \qquad .... \ (5.1)$$

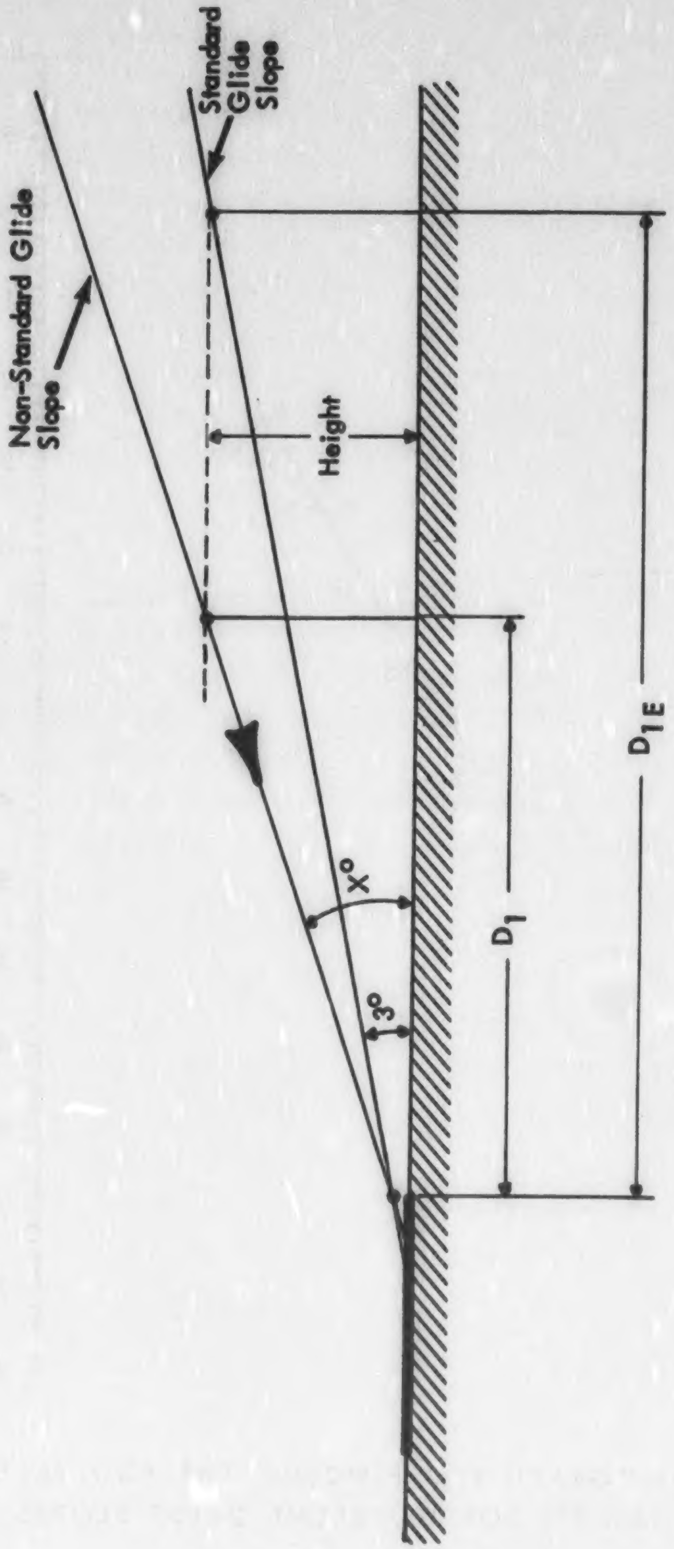

FIGURE 16. EQUIVALENT D_1 FOR NON-STANDARD OPERATION

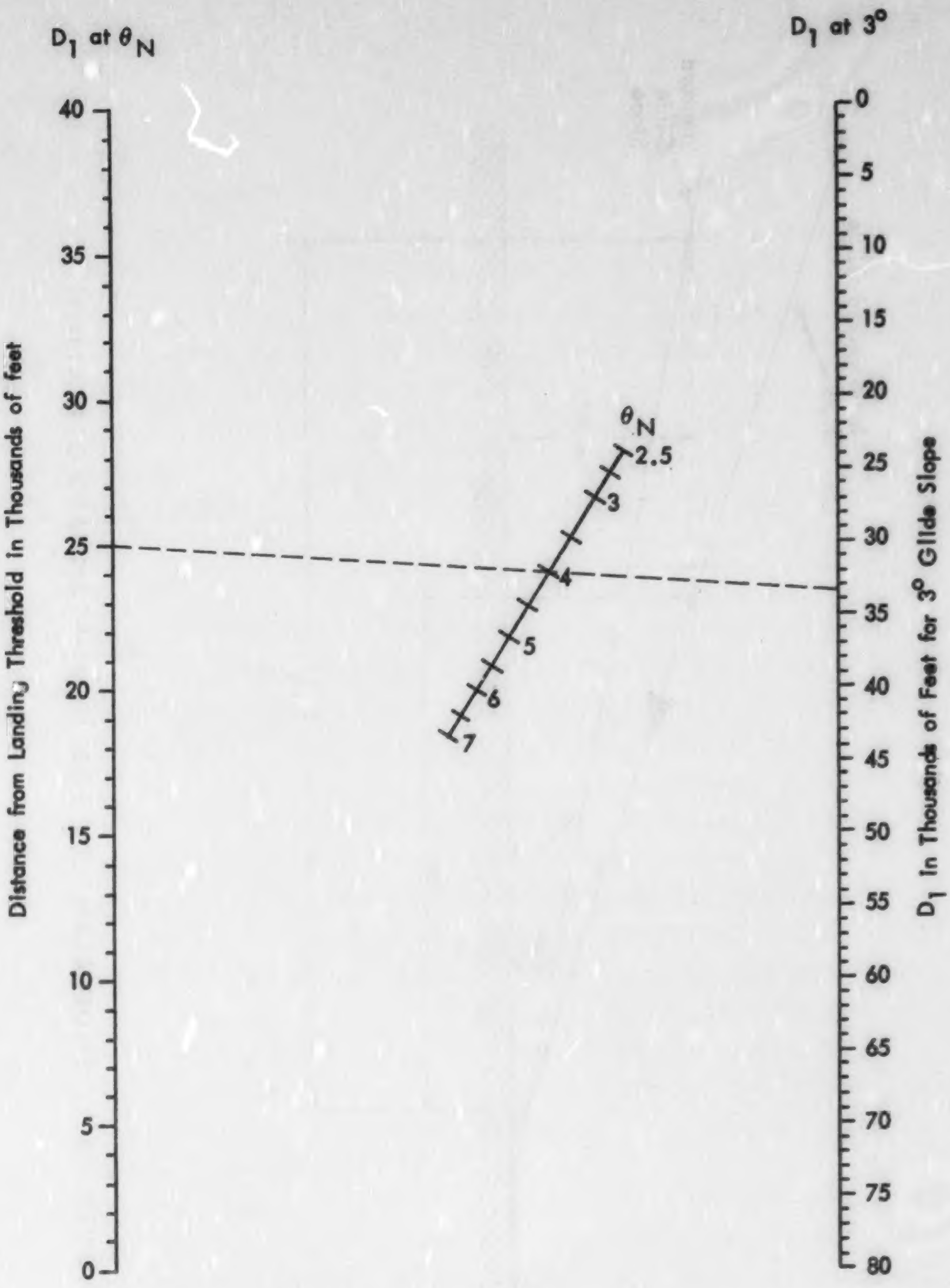

FIGURE 17. NOMOGRAPH FOR FINDING THE EQUIVALENT D_1 (AT 3°) FOR DIFFERENT GLIDE SLOPES

Example -

For a glide slope of 4° and distance D_1 of 25,000 ft., find the equivalent D_1 for a 3° glide slope. In Figure 17, draw a line through 25 on the left vertical scale (D_1 at θ_N) and through $\theta_N = 4°$. This line intersects the right vertical scale (D_1 at 3°) at 33,600 ft.

C. Guidance in Determining the Number of Positions for L_{dn} Calculations

For a small parcel of land calculation of the L_{dn} at one position is sufficient. For a larger parcel, where there may be a significant variation within the parcel boundaries, calculation at more than one point may be desirable. The practical question to be answered is, "What is a small land parcel?" This question can be answered by considering the accuracy of the calculations and the magnitude of the variations in noise levels that is felt to be significant. In the guidelines to follow, we shall consider a small parcel as one where the expected variation in L_{dn} or SEL values will be of the order of 1 dB or less. For such parcels, calculation at one position should be sufficient. A larger parcel is one where it is anticipated that the variation in noise levels will be larger than 1 dB. Given this definition, general guidelines can be developed that will apply for the cases where the aircraft is airborne -- the guidelines will not generally be accurate for positions off to the side of the runway where the land parcel is exposed to noise from aircraft generated as the aircraft moves along the runway prior to taking off.

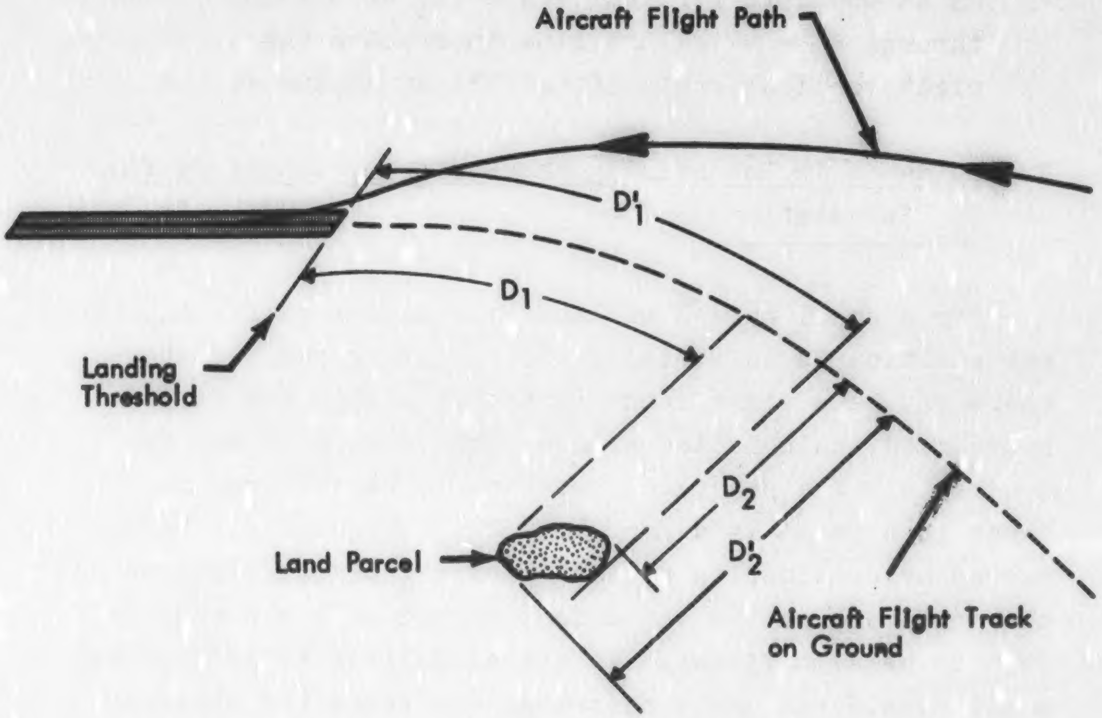

FIGURE 18. DEFINITION OF DISTANCES FOR DETERMINING LAND PARCEL "SIZE"

1. Determine D_1 and D_2 distances. Determine D_1 and D_1', and D_2 and D_2' as shown in Figure 18. Note that D_1 is the distance along the flight track to a perpendicular drawn from the flight track to the edge of the parcel *nearest the runway;* D_2' is the distance to the edge of the parcel *farthest from the runway.* Similarly, D_2 is the distance from along a perpendicular drawn from the flight track to the edge of the parcel *nearest the flight track* and D_2' is the distance to the edge of the parcel *farthest from the flight track.* Thus D_1 will always be large than D_1' and D_2 will always be larger than D_2'.

With the D_1 and D_2 distances determined, the formal guidelines described in the following steps may not be necessary in determining the need for calculating L_{dn} values at more than one position. One may simply estimate the expected variation in noise over the land parcel by inspection of the appropriate SEL charts, using the D_1 and D_2 values determined in this step.* Where several aircraft are involved, select the SEL charts for the aircraft likely to be the *dominant* aircraft, i.e. the aircraft likely to have the highest partial L_{dn} value.

2. Determine adjusted D_1 values. To apply the guidelines, the measured D_1 values, as obtained above, must be *adjusted* to represent the actual distance along the flight track from the point at which the aircraft left the ground.

**This approach must be used to estimate the variation in levels for a parcel exposed only to noise from aircraft during the takeoff roll.*

(a) For landings, the adjusted D_1 values (D_1^* and $D_1'^*$) are equal to the measured D_1 values *plus* 950 ft.

(b) For takeoffs, adjusted D_1 values are equal to measured D_1 values *minus* the distance from start of takeoff roll to the point at which the aircraft leaves the ground (liftoff point). The liftoff distance which is, of course, always less than the runway distance may be estimated from Figure B-3 through B-9 given in Appendix B. (High precision is not needed.)

3. Apply size tests. Calculate the quantity d where:

$$d = \frac{D_1'^* - D_1^*}{D_1^*}$$

If d is *less* than 0.12 the parcel may be considered to be *small* with regard to variations in noise along the direction of the flight track. If d is *equal to* 0.12 *or greater*, the parcel should be considered *large* and calculations at more than one position should be considered.

To estimate the variation in levels perpendicular to the flight track, enter Figure 19, with the two quantities:

$\frac{D_1^*}{D_2}$, measured along the horizontal axis

$\frac{D_2' - D_2}{D_2}$, measured along the vertical axis

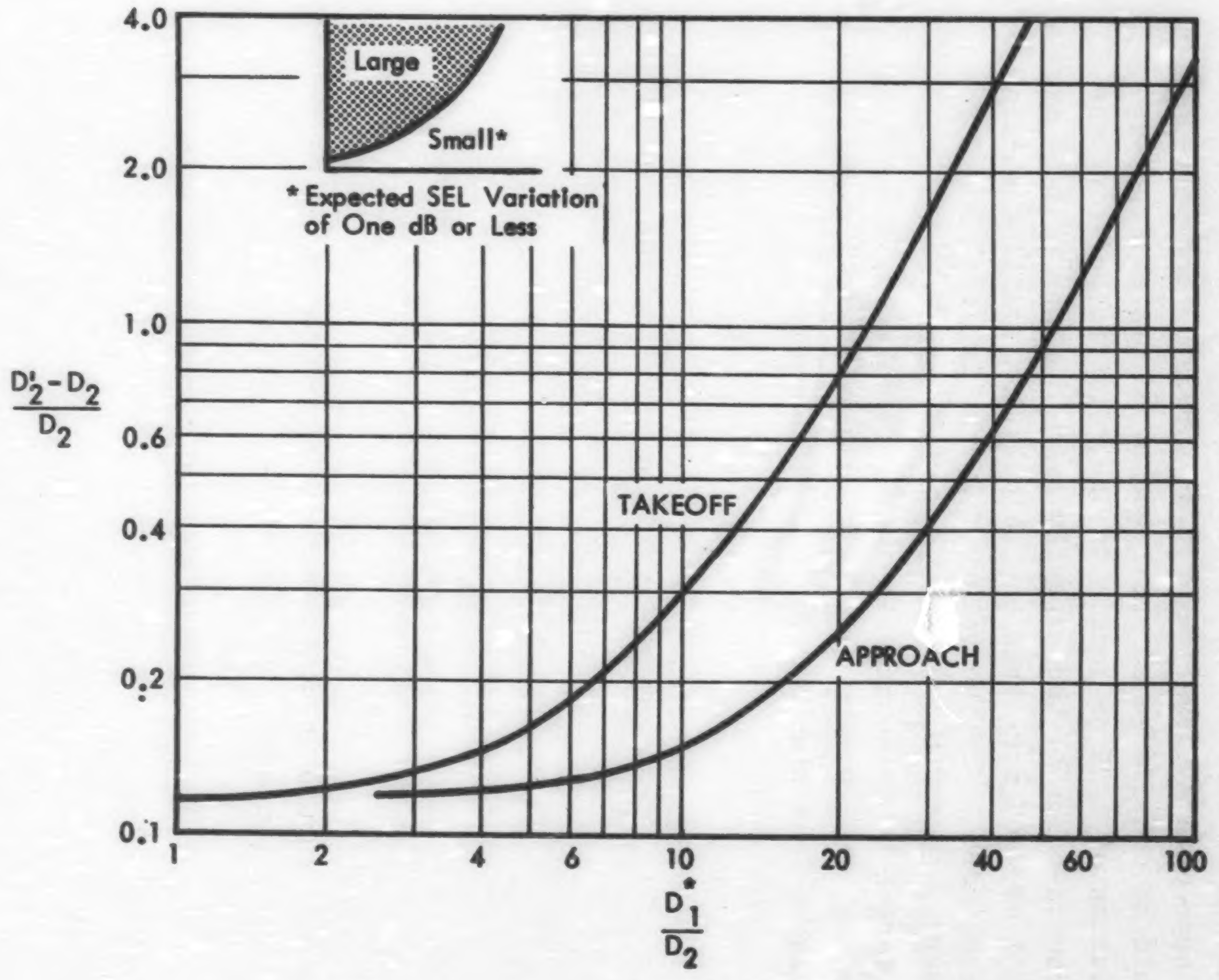

FIGURE 19. GUIDANCE CHART FOR DETERMINING LAND PARCEL "SIZE" WITH RESPECT TO SEL OR L_{dn} VARIATIONS

Locate the point on the figure. If this point falls below the appropriate curve (takeoff or approach) the parcel should be considered as small and hence has an expected variation of 1 dB or less. If the point falls above the appropriate curve, the expected variation may well be more than 1 dB, and more than one calculation position should be considered. If the value of D_1*/D_2 is less than 1 *for takeoffs,* $(D_2' - D_2)/D_2$ should be less than the 0.1 for the parcel to be considered small. Similarly, for the approach, when D_1*/D_2 is less than 2.4, $(D_2' - D_2)/D_2$ should be less than 0.1 for a small parcel.

REFERENCES

1. N. H. Reddingius, "Community Noise Exposure Resulting from Aircraft Operations: Computer Program Operator's Manual," AMRL TR 73-108, Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, July 1974.

2. C. Bartell et al, "Airport Noise Reduction Forecast, Volume II - NEF Computer Program Description and User's Manual", Dept. of Transportation, DOT-TST-75-4, October 1974.

3. FAA Form 5010-1 (7-70) or replacement "FAA Airport Master Record".

4. National Ocean Survey, Distribution Division, C44, Riverdale, Md. 20840.

5. Jeppesen and Co., 8025 E-40th Ave., Denver, Colo. 80207.

6. "Utility Airports - Air Access to National Transportation, Appendix 3, Weather Data Source and Analysis", FAA Advisory Circular AC 150/5300-4B, June 1975.

APPENDIX A

SEL CHARTS

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APPENDIX A

This appendix contains the sound exposure level (SEL) charts needed for calculation of day-night levels (L_{dn}) for civil aircraft operations. The selection of the appropriate noise chart is determined by:

- Aircraft type
- Mode of operation (takeoff or landing)
- Distance D_1*

Aircraft types for which SEL information is provided are identified in Table A-1 of this appendix. The types are listed in order of approximate noisiness. Table A-2 provides an index to the individual noise charts.

Each noise chart covers a range of the distance D_1, and several charts may be needed to cover the entire range of D_1 values for each aircraft and mode of operation.

Noise charts are identified according to the code listed below. This shows an example of the coding used by the charts for the basic L_{dn} calculation:

4 - T - TFL(Q) - TO(I) - N - 1

(1) (2) (3) (4) (5) (6)

(1) The first number identifies the number of engines in the aircraft.

---

*Distances D_1 and D_2 are defined in the text (See Figures 3 and 4).

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(2) This letter signifies either transport aircraft (T) or general aviation aircraft (G).

(3) The next group of letters identifies the type of engine, as follows:

TJ - Turbojet
TFL - Low bypass ratio turbofan
TFH - High bypass ratio turbofan
TP - Turboprop
PP - Propeller driven by reciprocating engine
LPP - Propeller driven by reciprocating engine (large)
SPP - Propeller driven by reciprocating engine (small)
TFS - Turbofan (small)

The appendix (Q) signifies a quiet nacelle engine

(4) The mode of operation is identified with a TO for takeoff and L for landing. (I), (II) or (III) refers to the takeoff profiles associated with different flight stage lengths when a detailed noise analysis is being performed (see Section V-A). If the stage length is not known, use profile (II).

(5) This group of letters refers to the special procedure that may be used. The interpretation of the coding is as follows:

S - Standard takeoff
N - Northwest Orient Airlines noise abatement takeoff

F - FAR Part 36 takeoff
T - Two-segment approach

(6) The last number of the code identifies the number in the set. The graphs within a set encompass different ranges of the distance D_1. For the turbojet and turbofan aircraft there are usually three graphs in a takeoff set and two graphs in a landing set. For the turbojet and turbofan aircraft there are usually three graphs in a takeoff set and two graphs in a landing set. For the propeller aircraft there are two graphs in a takeoff set and one graph in a landing set.

TABLE A-1

NOISE CHART CODES ASSOCIATED WITH AIRCRAFT TYPES

RANKED BY APPROXIMATE NOISINESS

Aircraft Type	Aircraft Code	Typical Aircraft	Takeoff SEL at 15,000 ft. from Start of TO[1], dB	Landing SEL at 6,000 ft. from Threshold[2], dB
4-Engine HBPR turbofan	4-T-TFH	747	111.5	108.3
4-Engine LBPR turbofan	4-T-TFL	707, DC-8	110.9	106.4
4-Engine LBPR turbofan (quiet nacelle)	4-T-TFL(Q)	707(QN) DC-8(QN)	109.7	97.2
3-Engine LBPR turbofan	3-T-TFL	727	109.6	101.1
3-Engine LBPR turbofan (quiet nacelle)	3-T-TFL(Q)	727(QN)	109.3	96.1
4-Engine HBPR turbofan (quiet nacelle)	4-T-TFH(Q)	747(QN)	108.6	103.1
2-Engine Composite Business Jet (turbojet/turbofan)	2-G-TJ	Jetstar I, Learjet 23-25, Learjet 35-36, Jetstar II	104.9	101.3
2-Engine LBPR turbofan	2-T-TFL	737, DC-9	101.9	94.3
2-Engine LBPR turbofan	2-T-TFL(Q)	737(QN), DC-9(QN)	101.9	93.1
3-Engine HBPR turbofan	3-T-TFH	L-1011, DC-10	101.8	98.8
4-Engine propeller	4-T-PP	DC-4, DC-6	98.8	90.3
4-Engine turboprop	4-T-TP	Electra	97.8	92.1
2-Engine G.A.[3] turboprop	2-G-TP	Twin Otter, King Air, Turbo Commander	93.5	92.4
2-Engine G.A.[3] propeller (large)	2-G-LPP	DC-3	92.5	87.3
2-Engine G.A.[3] propeller (small)	2-G-SPP	Cessna 310-401	83.2	80.5
2-Engine G.A.[3] turbofan (small)	2-G-TFS	Cessna Citation	81.4	80.3
1-Engine G.A.[3] propeller	1-G-PP	Cessna 150-210, Piper Cher.140-235	81.8	72.9

[1] ATA (Air Transport Association) takeoff procedure at max. weight category

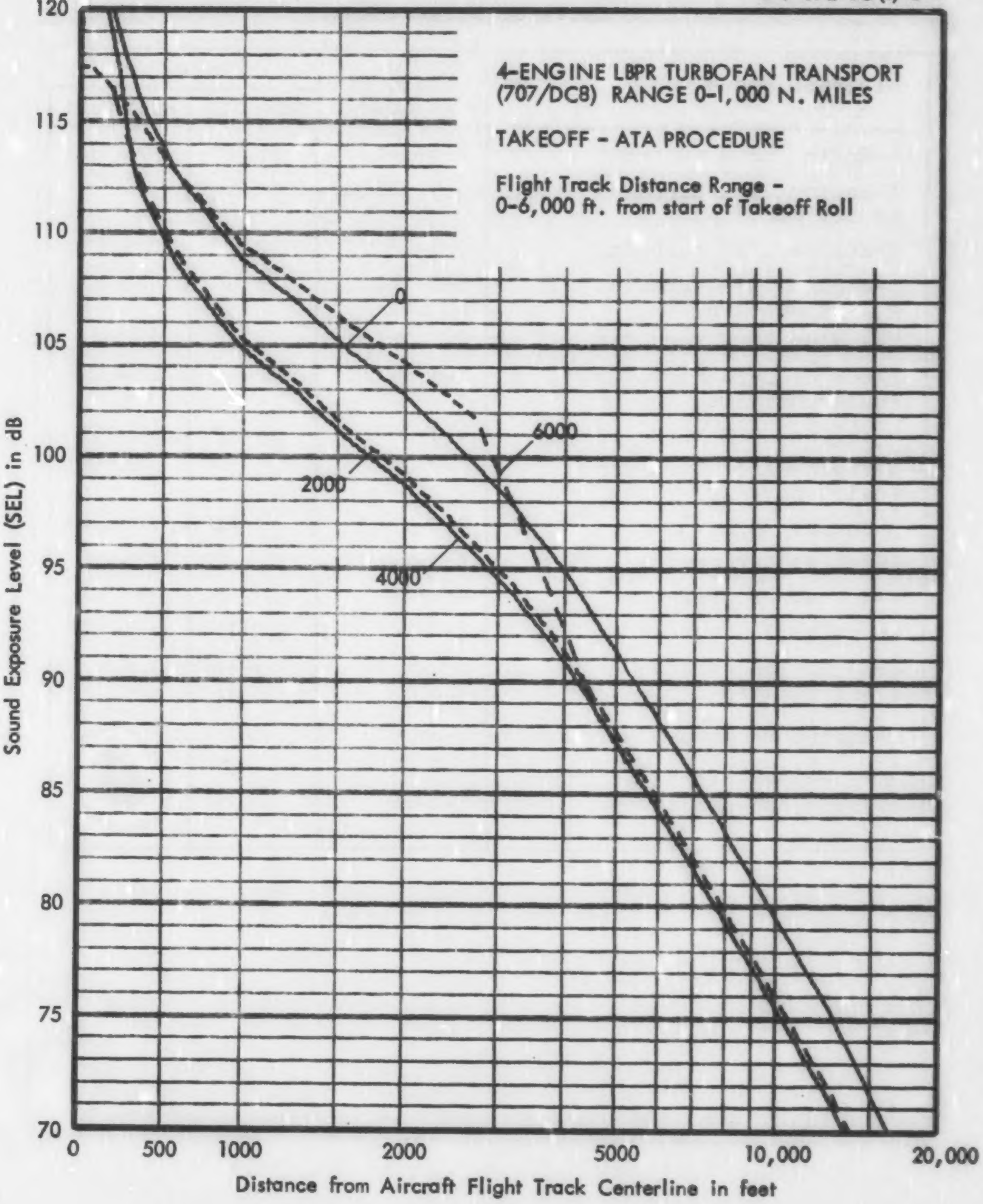
[2] 3° approach

[3] General aviation

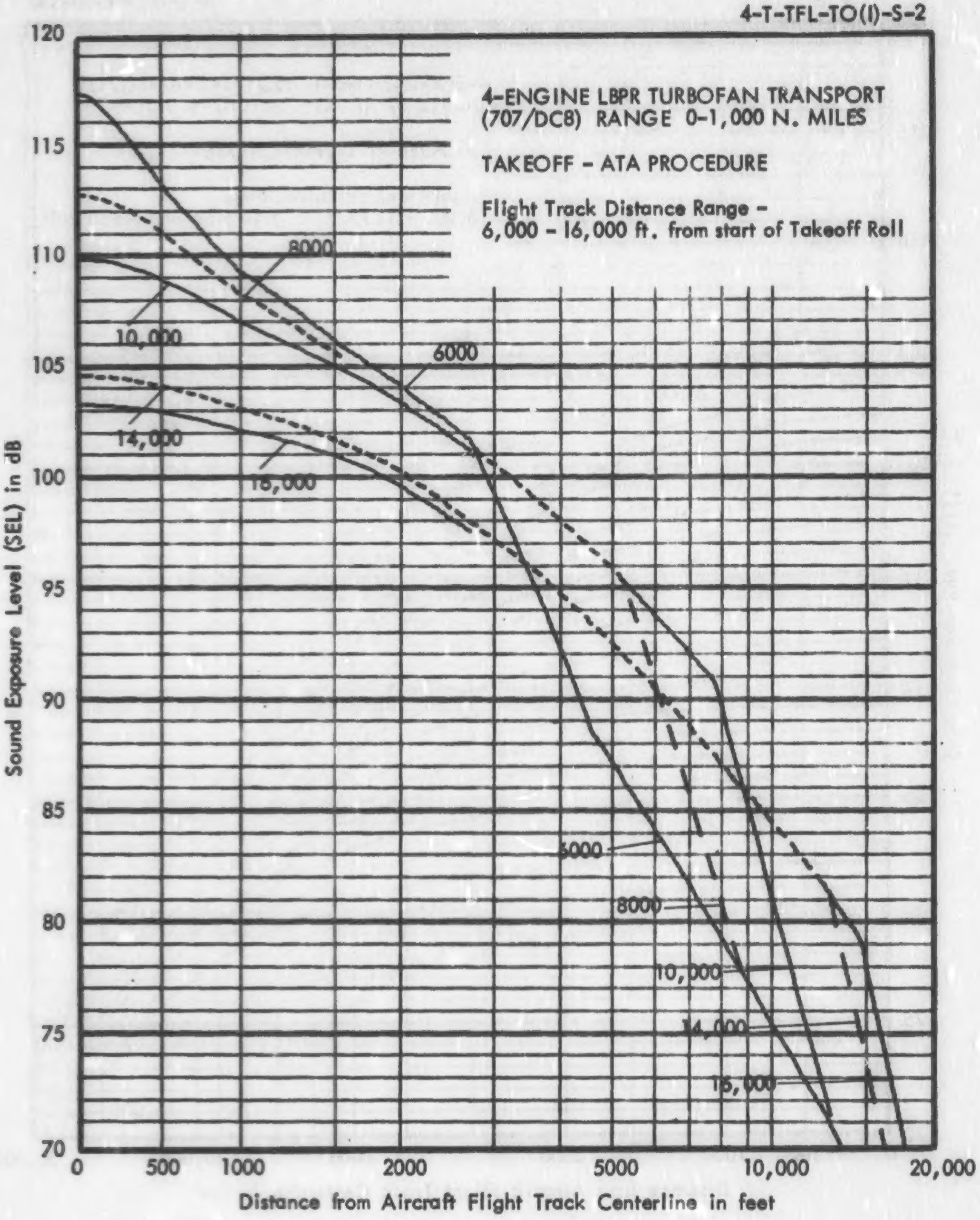
TABLE A-2

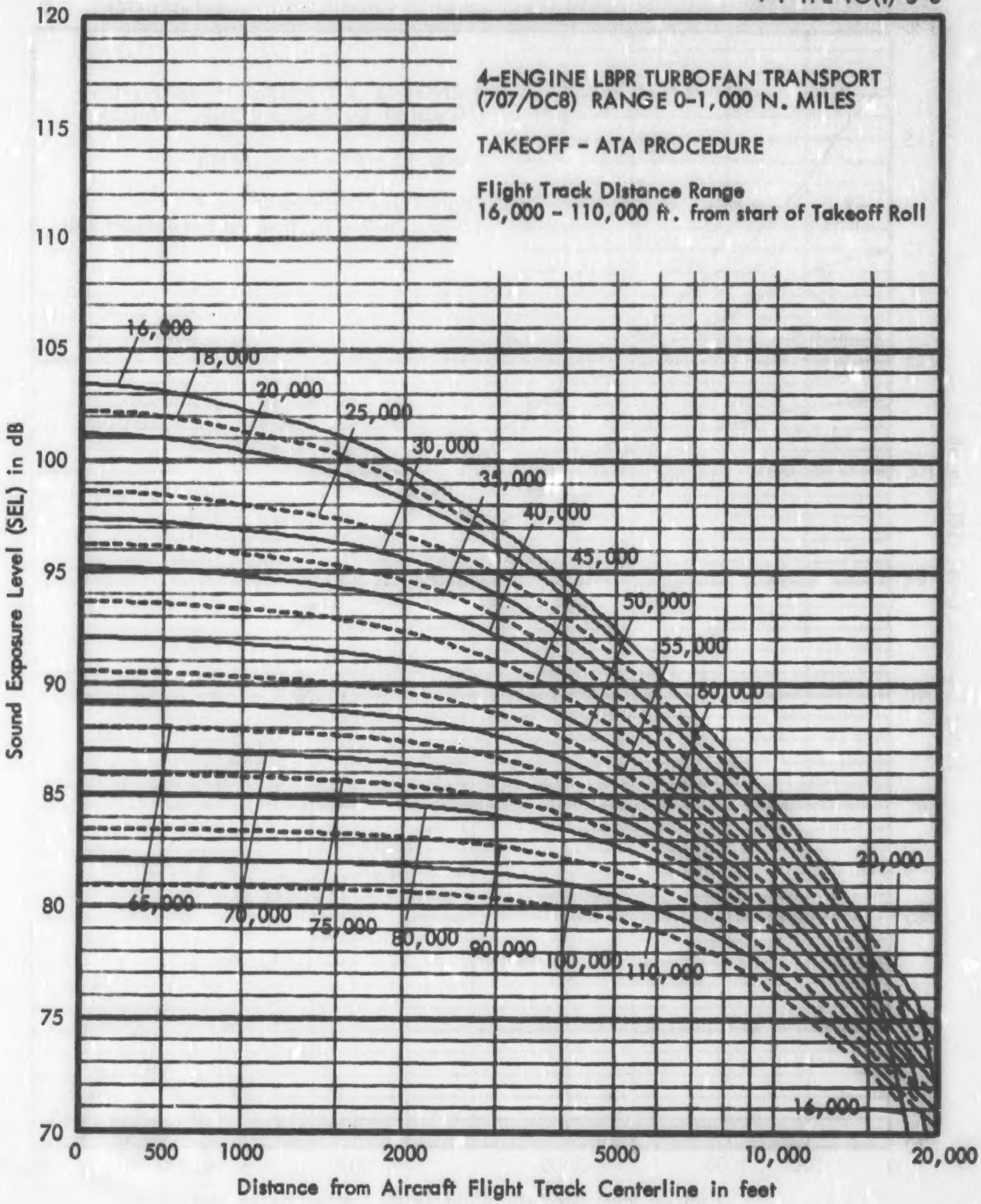
Index of Noise Charts

Aircraft Types	Aircraft Code	Pages	
		Takeoff	Approach
4-Engine LBPR turbofan	4-T-TFL	80-106	107-110
4-Engine LBPR turbofan (quiet nacelle)	4-T-TFL(Q)	111-137	138-141
3-Engine LBPR turbofan	3-T-TFL	142-159	160-163
3-Engine LBPR turbofan (quiet nacelle)	3-T-TFL(Q)	164-181	182-185
2-Engine LBPR turbofan	2-T-TFL	186-203	204-207
2-Engine LBPR turbofan (quiet nacelle)	2-T-TFL(Q)	208-225	226-228
4-Engine HBPR turbofan	4-T-TFH	229-255	256-259
4-Engine HBPR turbofan (quiet nacelle)	4-T-TFH(Q)	260-286	287-290
3-Engine HBPR turbofan	3-T-TFH	291-327	318-321
4-Engine turboprop	4-T-TP	322-324	325-326
4-Engine propeller	4-T-PP	327-329	330-331
2-Engine GA turbojet	2-G-TJ	332-334	335-336
2-Engine GA turbofan	2-G-TFS	337-338	339
2-Engine GA turboprop	2-G-TP	340-341	342
2-Engine GA propeller(large)	2-G-LPP	343-344	345
2-Engine GA propeller(small)	2-G-SPP	346-347	348
1-Engine GA propeller	1-G-PP	349-350	351

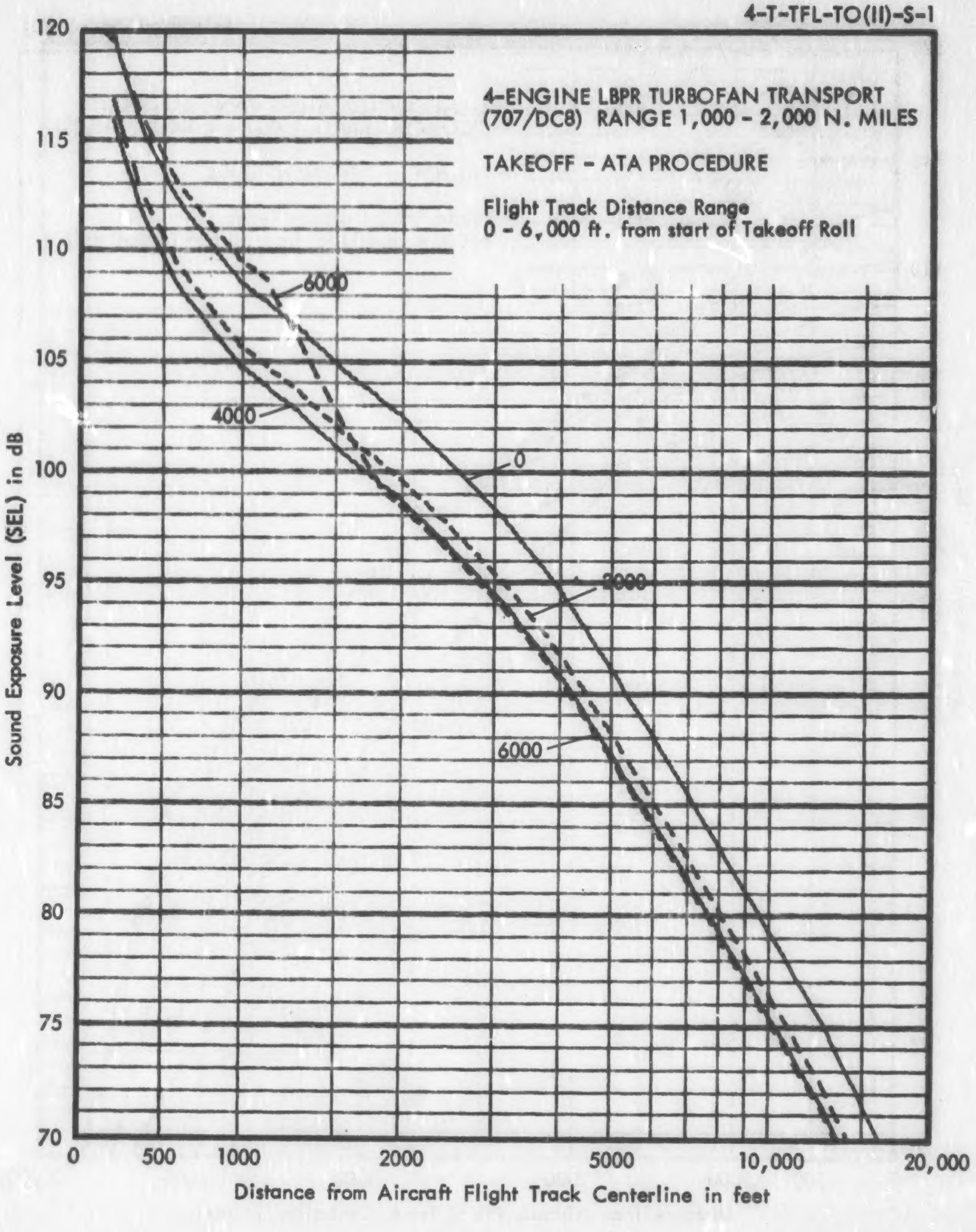

4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0-1,000 N. MILES
TAKEOFF - ATA PROCEDURE
Flight Track Distance Range -
0-6,000 ft. from start of Takeoff Roll
0
2000
4000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

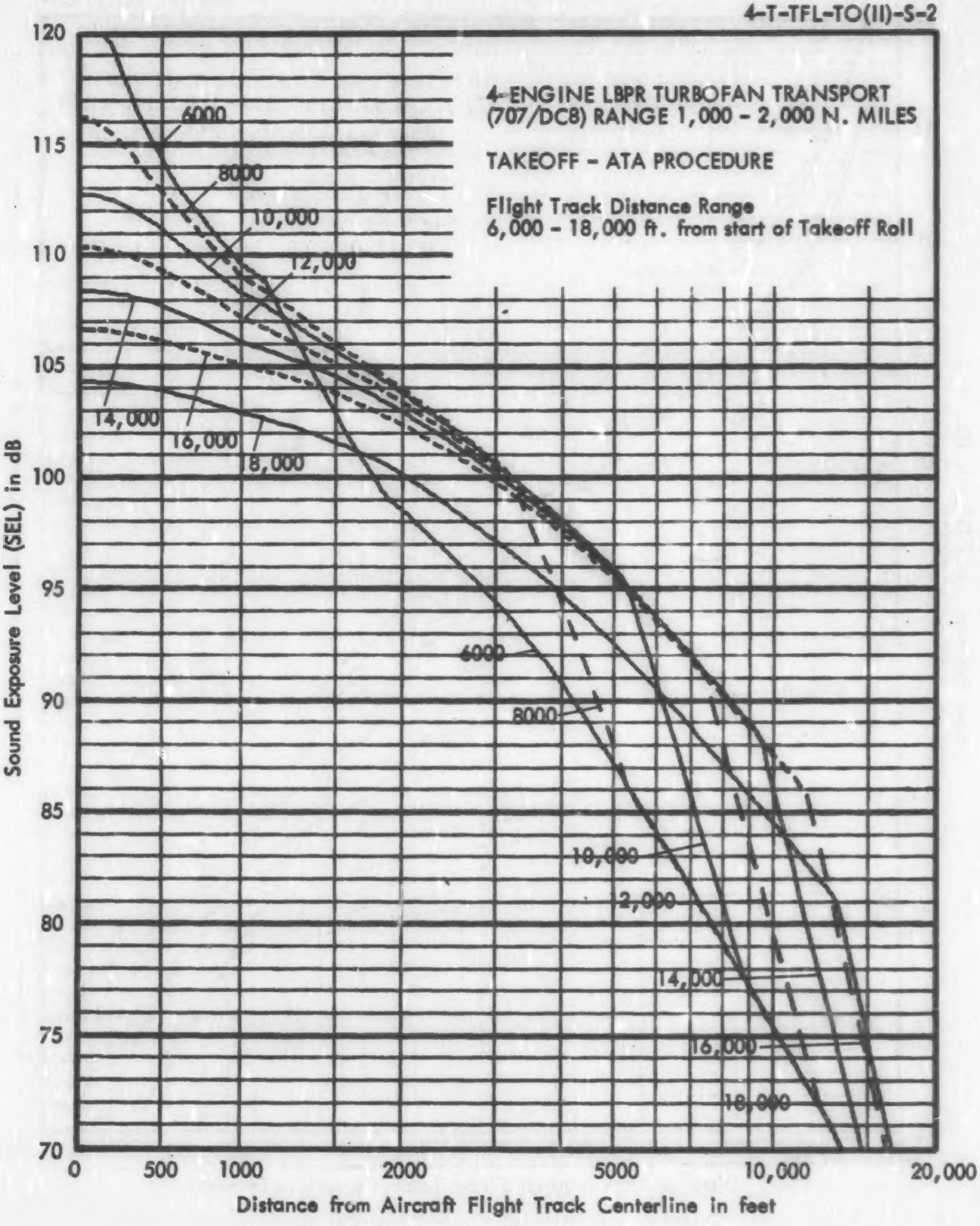
4-T-TFL-TO(I)-S-2


4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0-1,000 N. MILES
TAKEOFF - ATA PROCEDURE
Flight Track Distance Range -
6,000 - 16,000 ft. from start of Takeoff Roll
8000
10,000
6000
14,000
16,000
6000
8000
10,000
14,000
16,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0-1,000 N. MILES
TAKEOFF - ATA PROCEDURE
Flight Track Distance Range
16,000 - 110,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
55,000
60,000
65,000
70,000
75,000
80,000
90,000
100,000
110,000
20,000
16,000

4-T-TFL-TO(II)-S-1



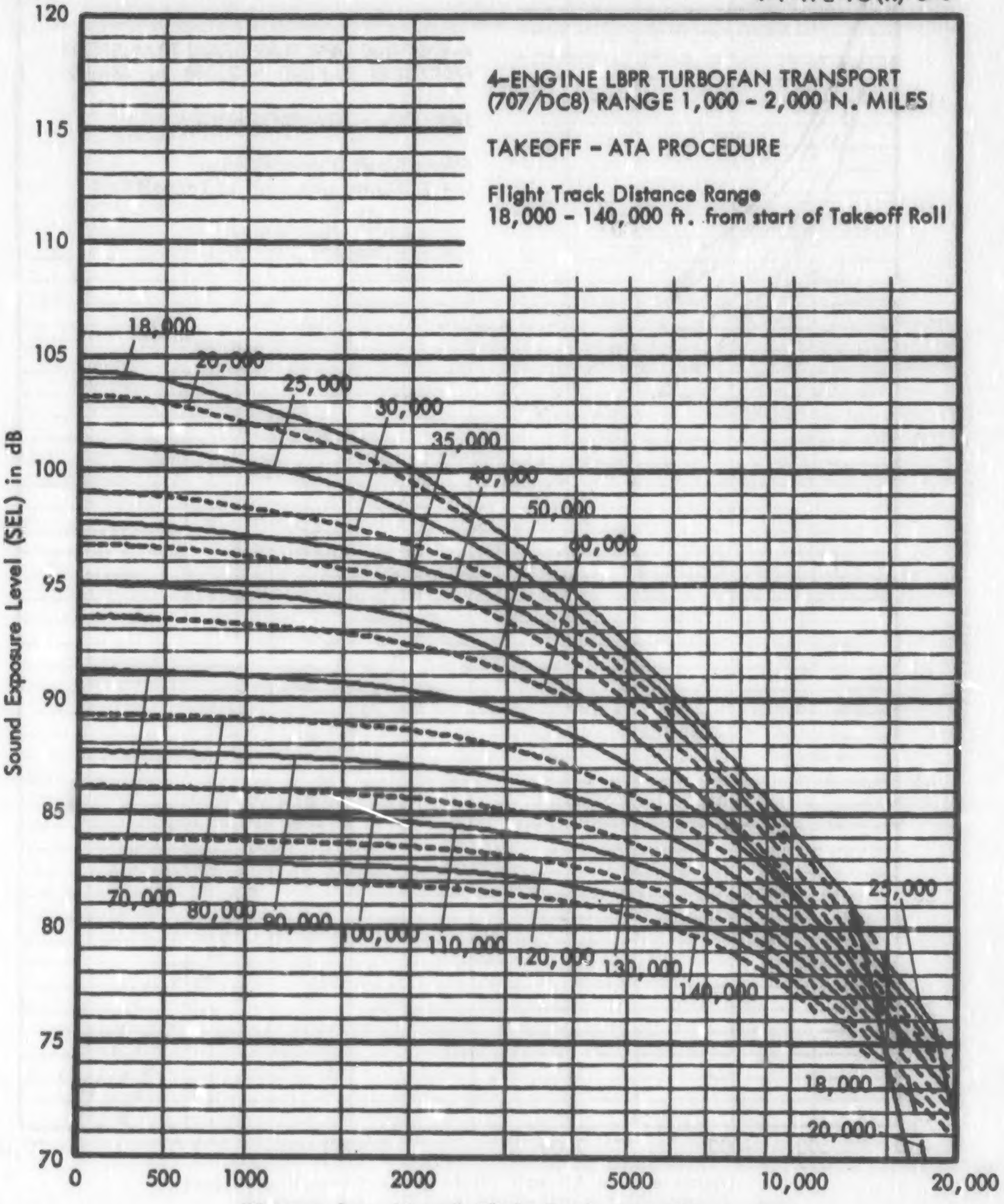


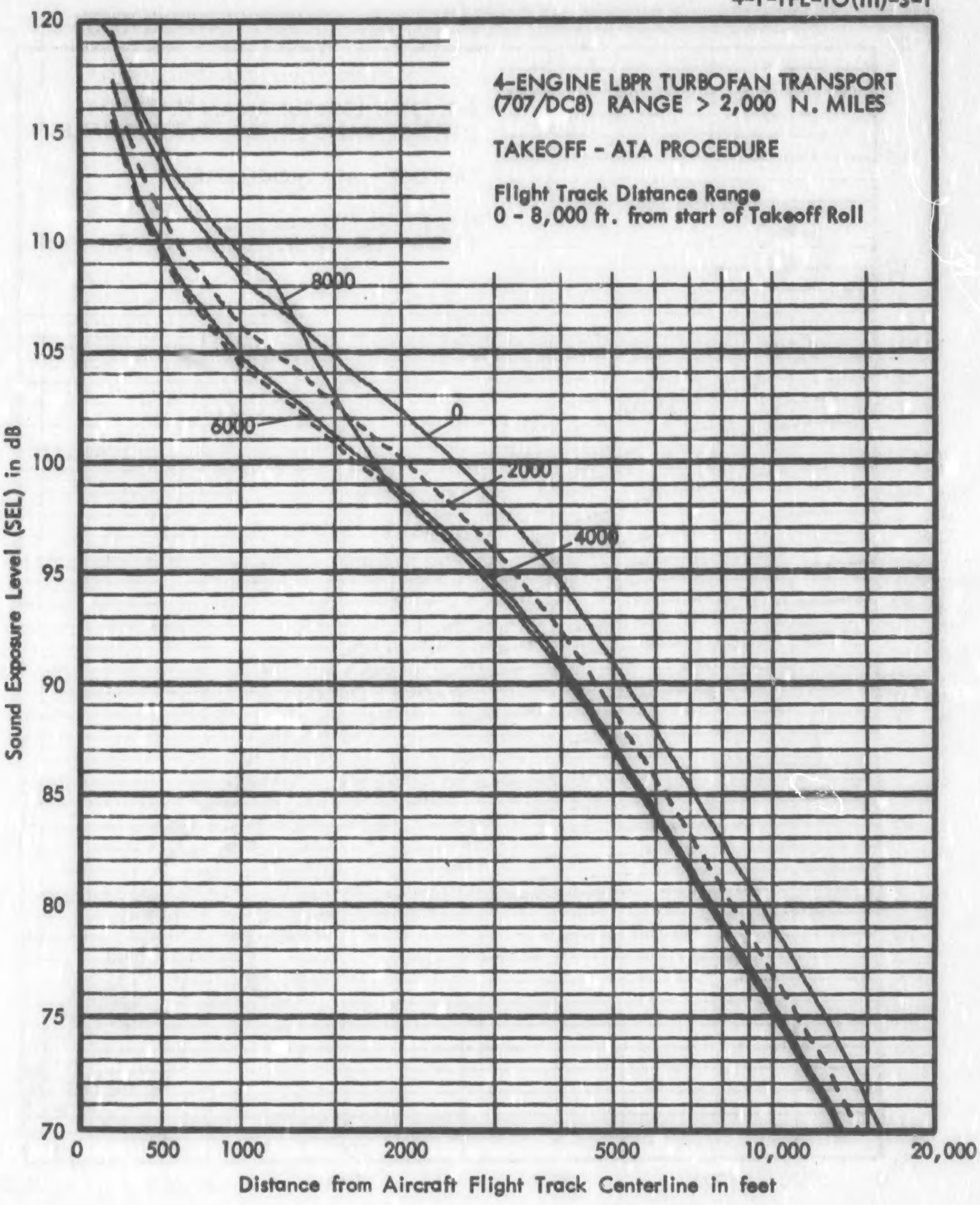
4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 1,000 - 2,000 N. MILES

TAKEOFF - ATA PROCEDURE

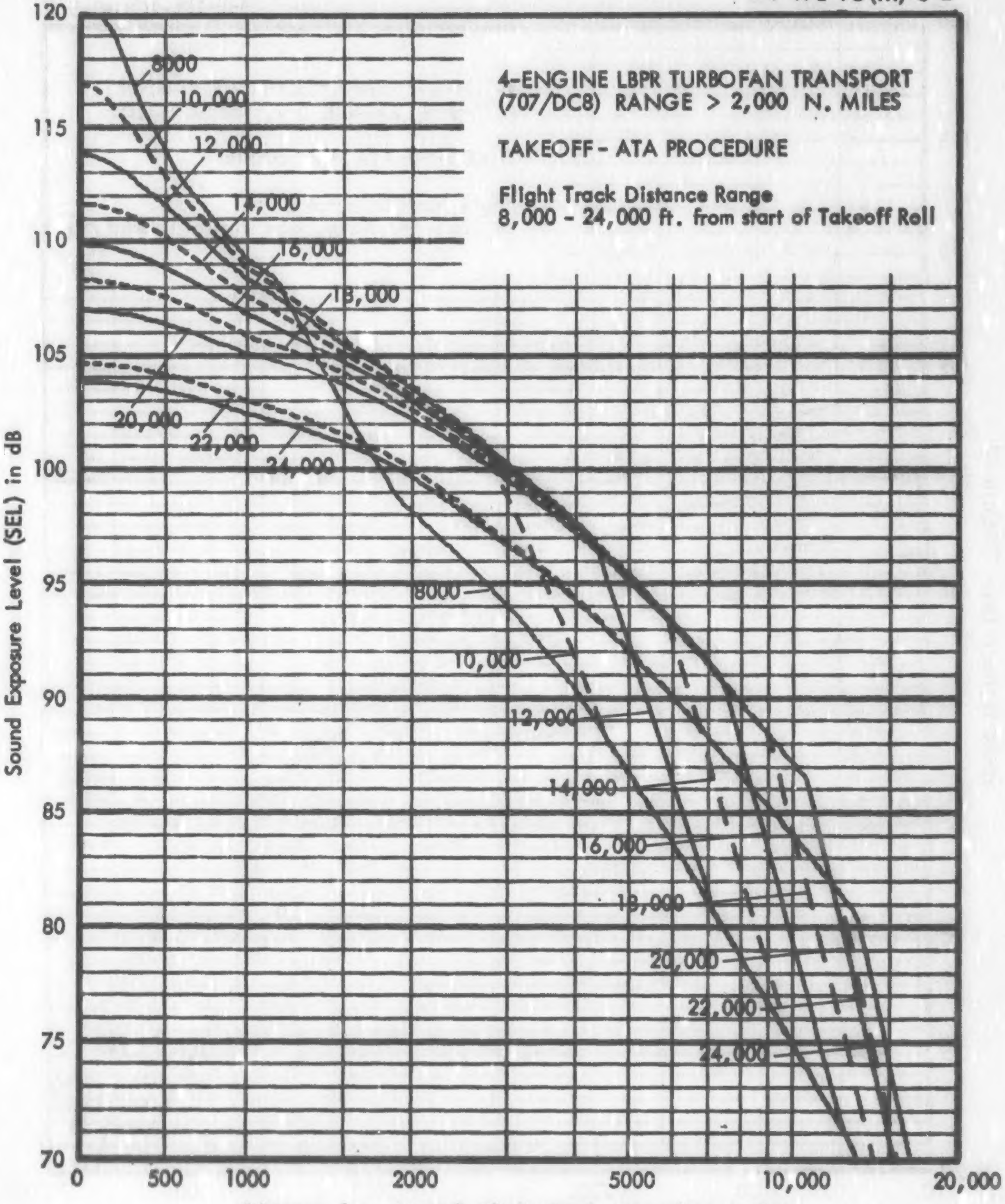
Flight Track Distance Range
6,000 - 18,000 ft. from start of Takeoff Roll

4-T-TFL-TO(II)-S-3

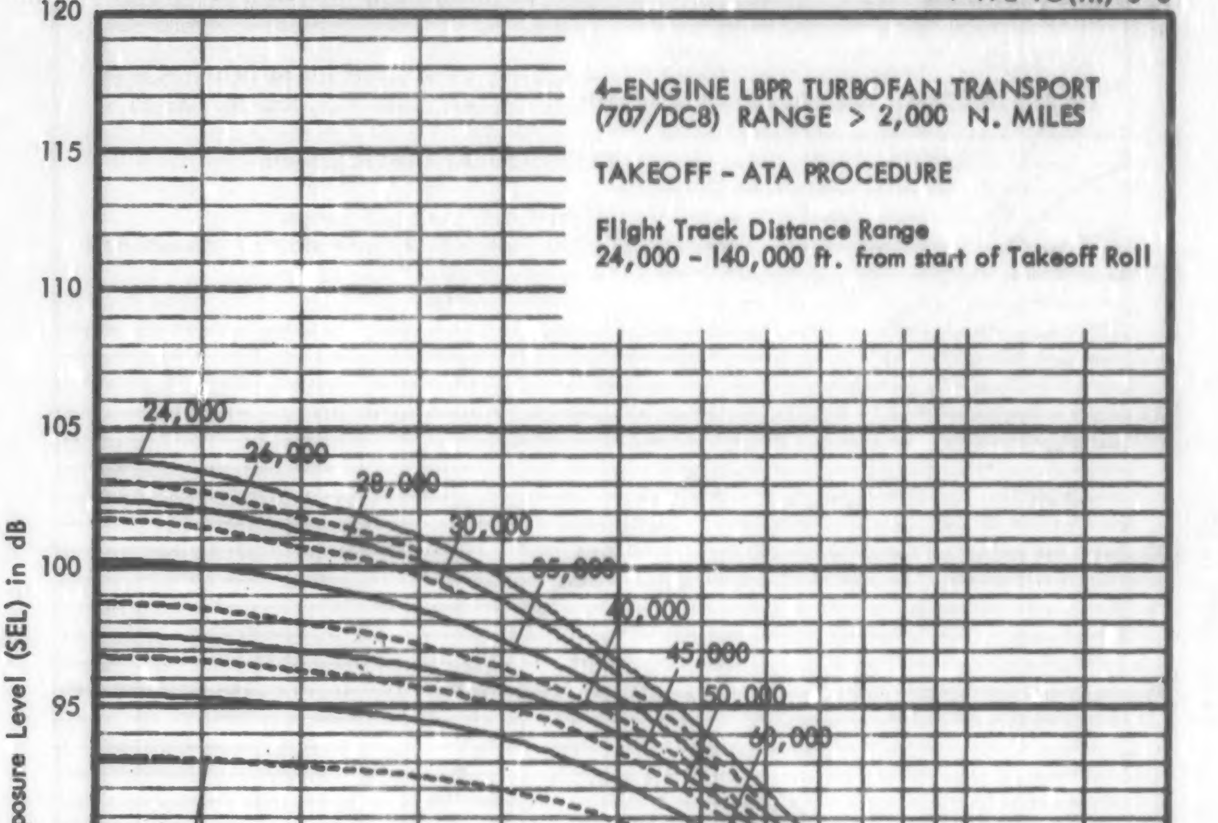



4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE > 2,000 N. MILES
TAKEOFF - ATA PROCEDURE
Flight Track Distance Range
0 - 8,000 ft. from start of Takeoff Roll
8000
6000
0
2000
4000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

4-T-TFL-TO(III)-S-2



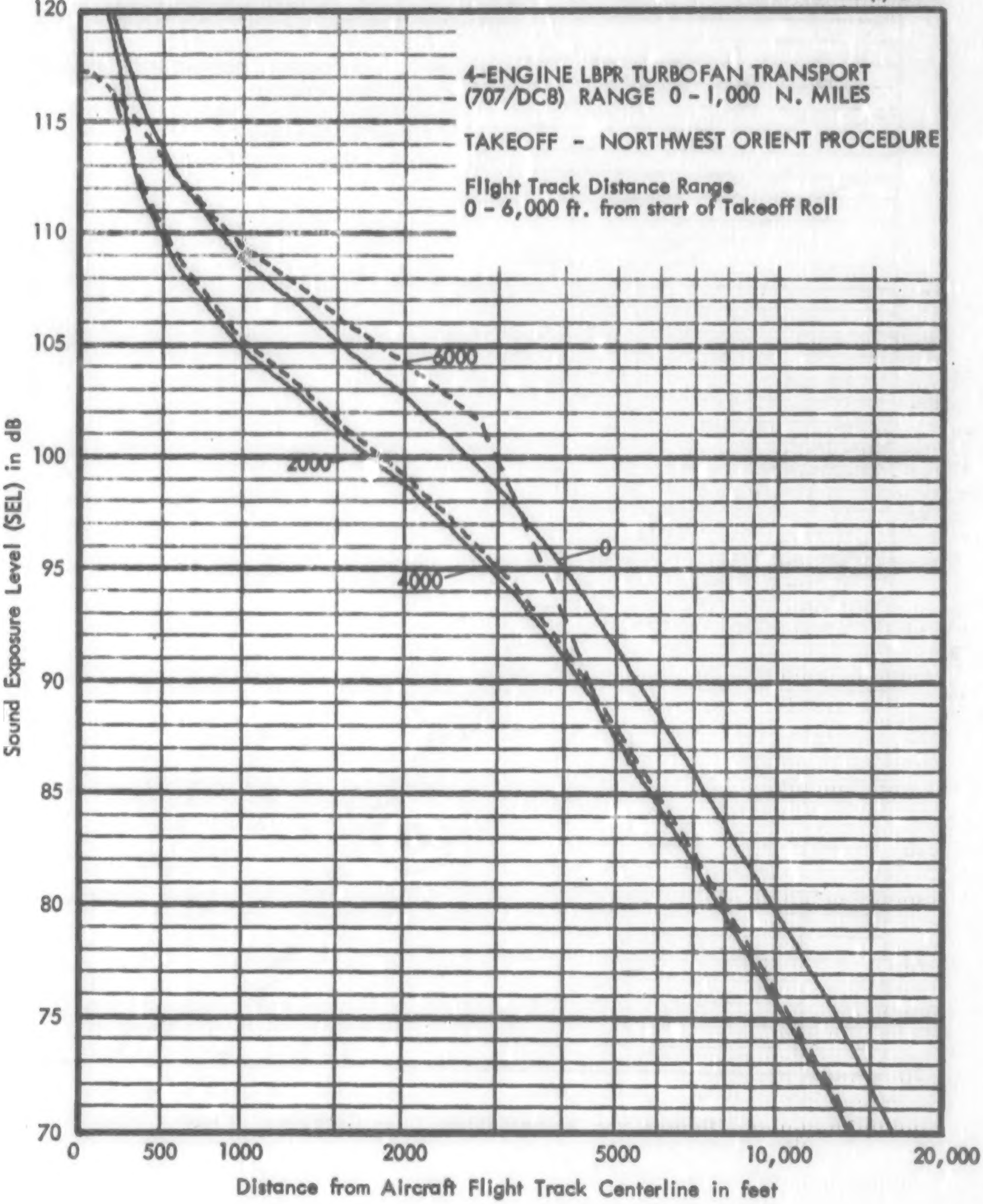
4-T-TFL-TO(III)-S-3

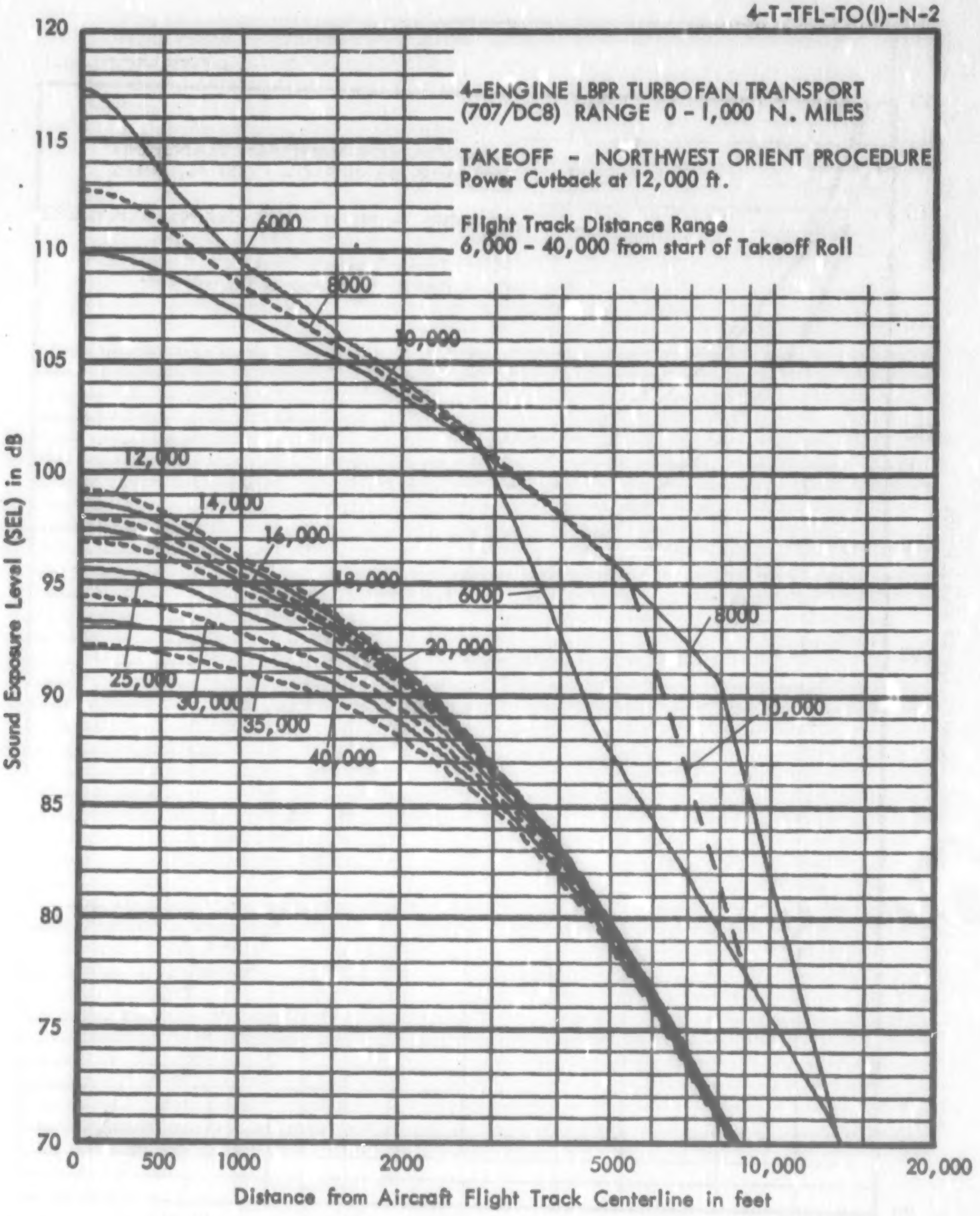


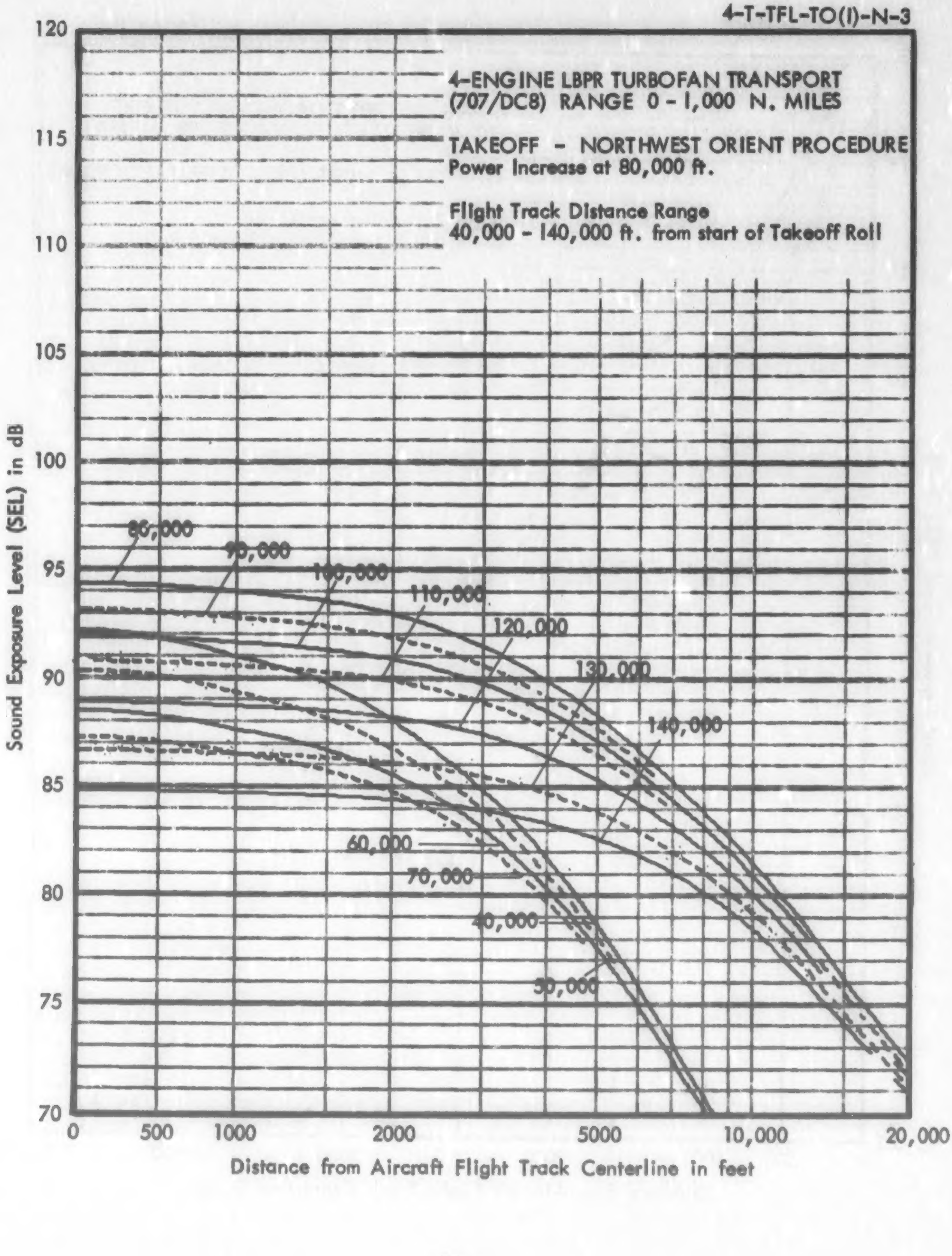
4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE > 2,000 N. MILES

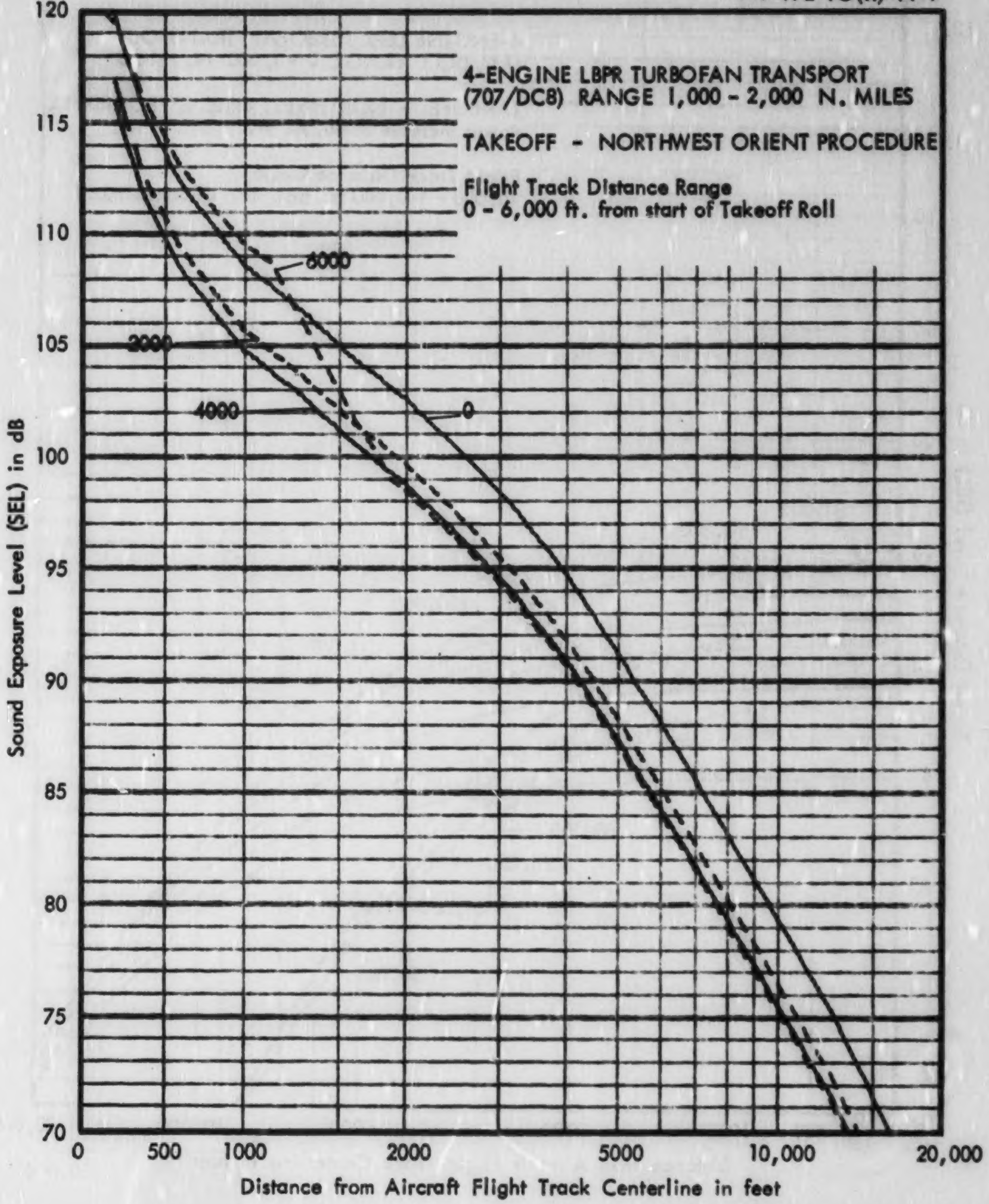
TAKEOFF - ATA PROCEDURE

Flight Track Distance Range
24,000 - 140,000 ft. from start of Takeoff Roll

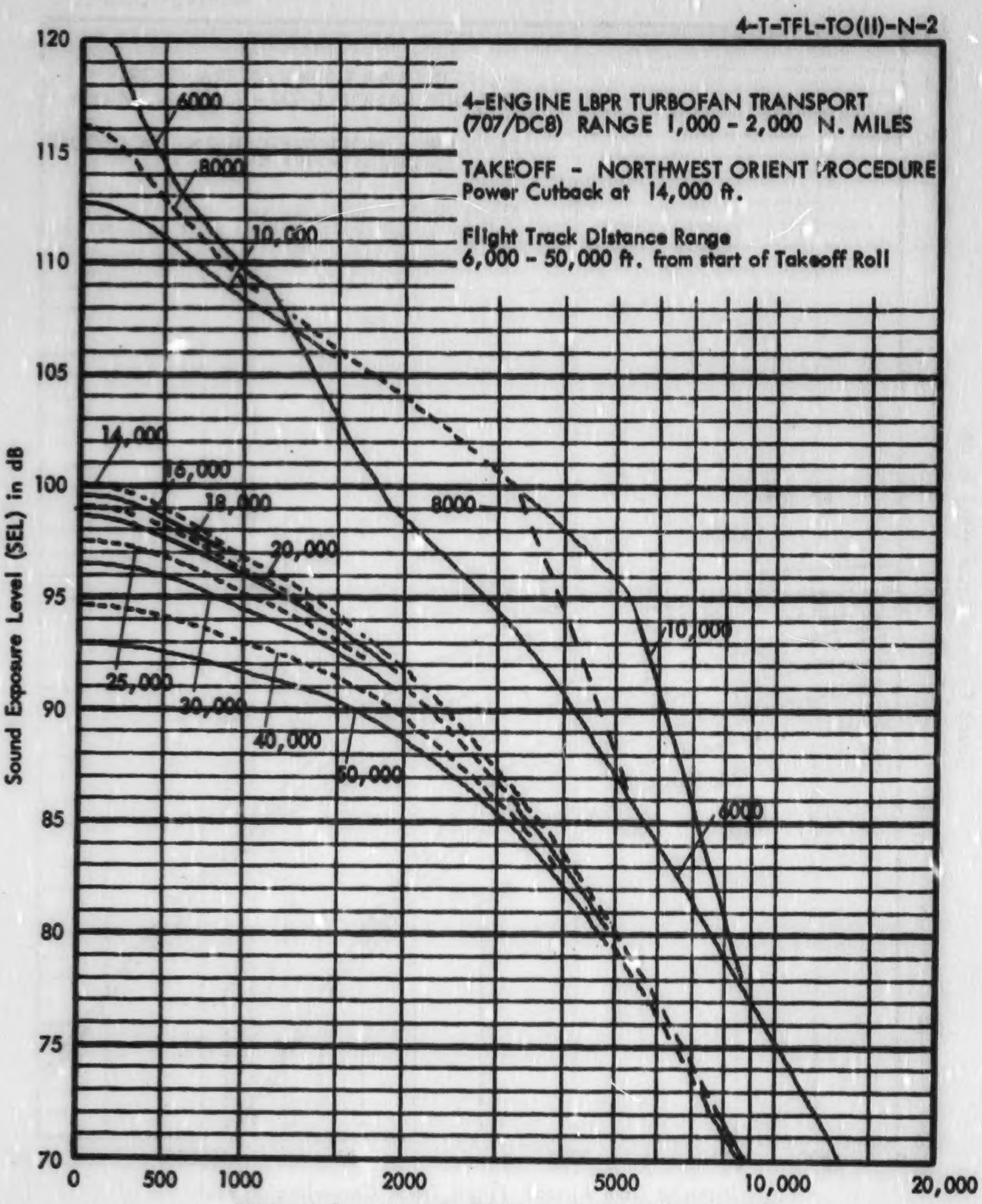

4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
6000
2000
0
4000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 12,000 ft.
Flight Track Distance Range
6,000 - 40,000 from start of Takeoff Roll
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
6000
8000
10,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

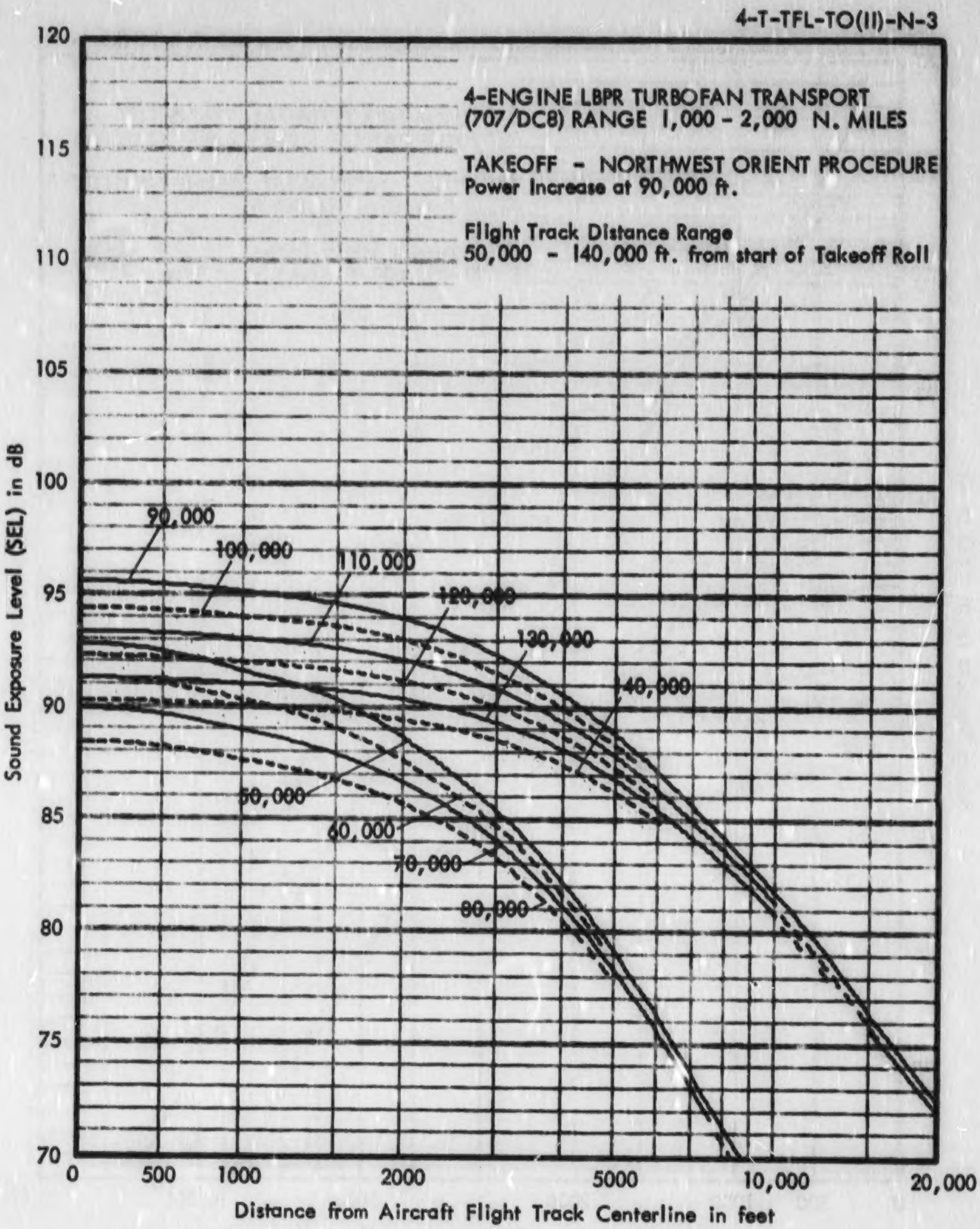

4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 80,000 ft.
Flight Track Distance Range
40,000 - 140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
80,000
90,000
100,000
110,000
120,000
130,000
140,000
60,000
70,000
40,000
50,000


4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
6000
2000
4000
0
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

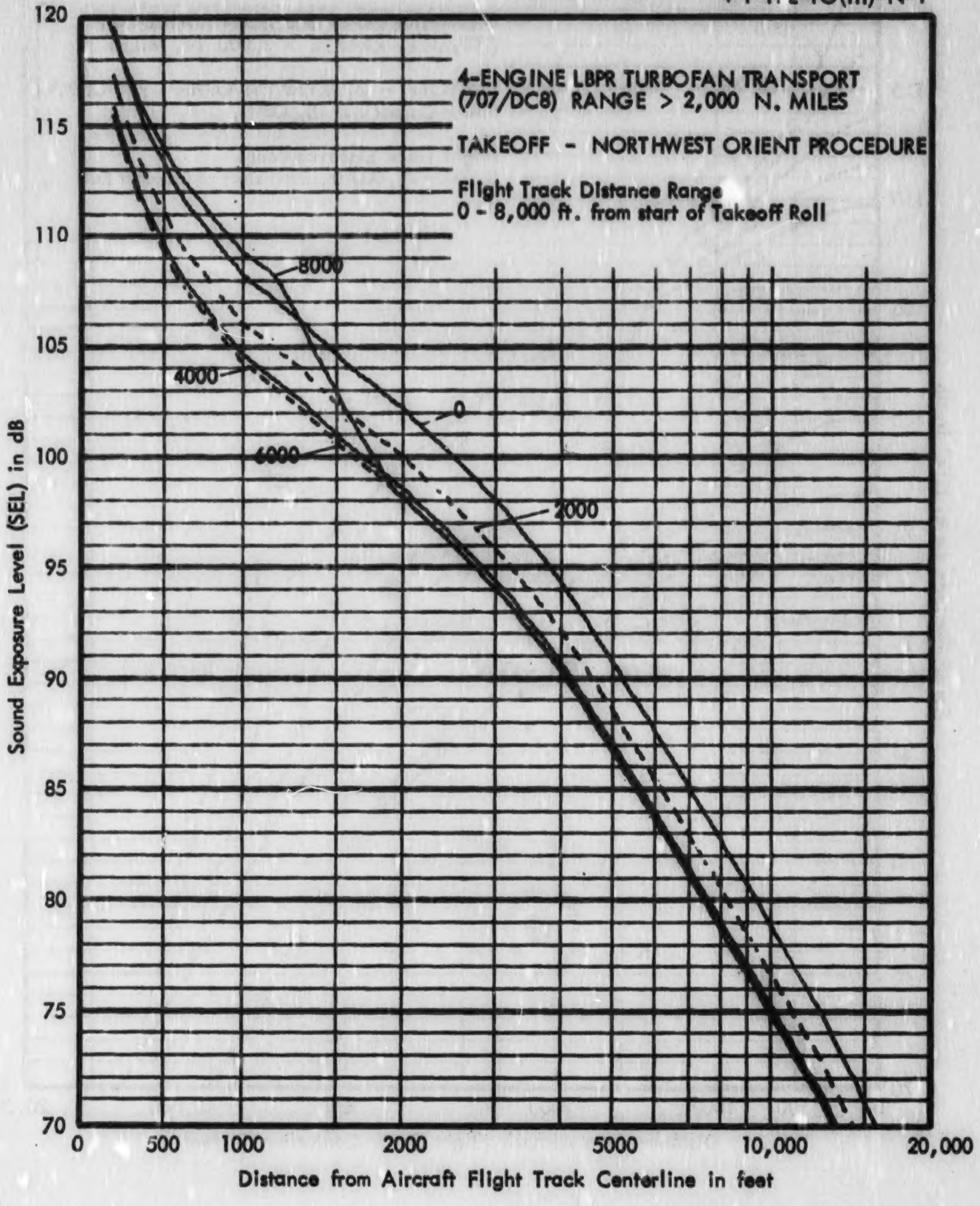
4-T-TFL-TO(II)-N-2



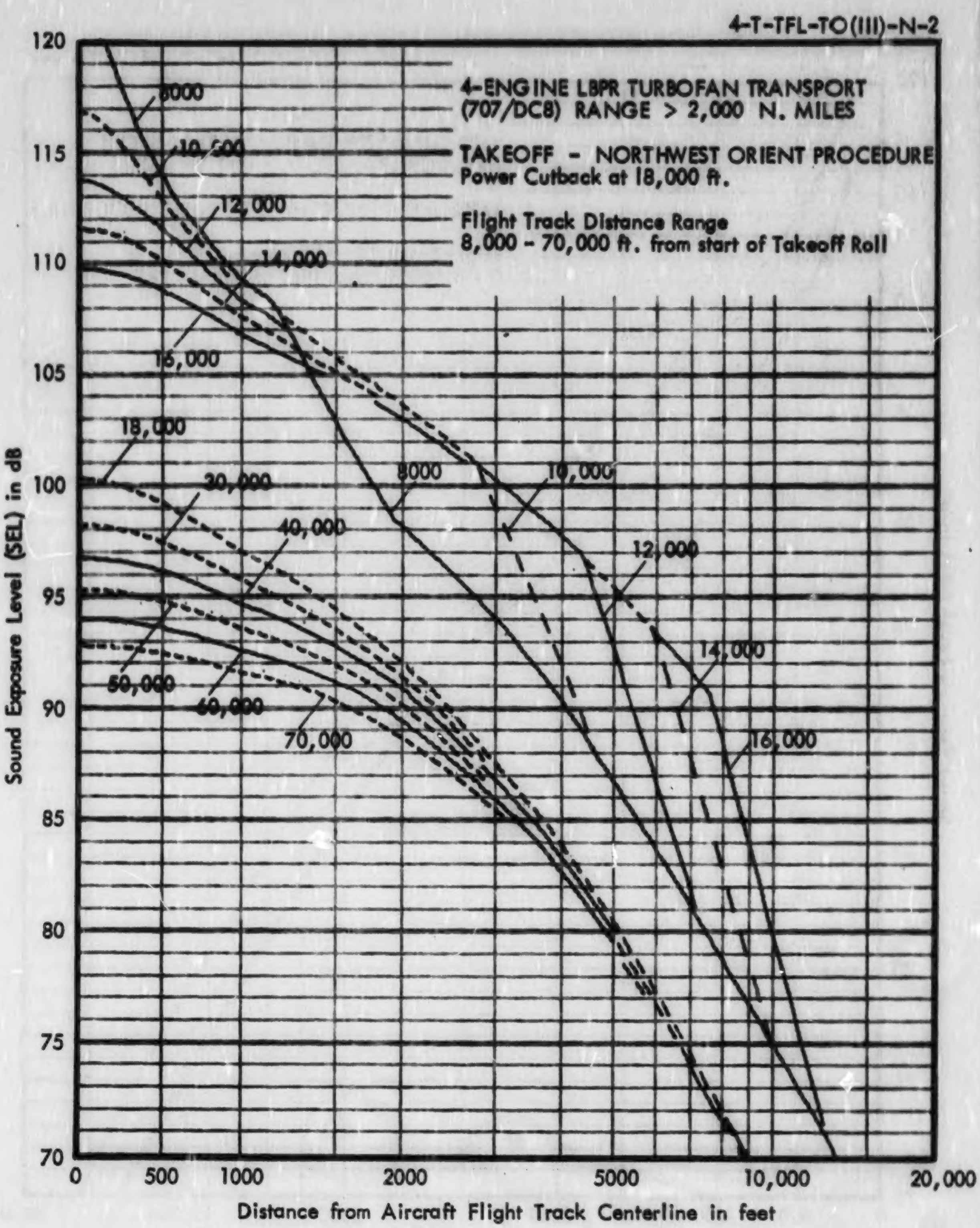
4-T-TFL-TO(II)-N-3



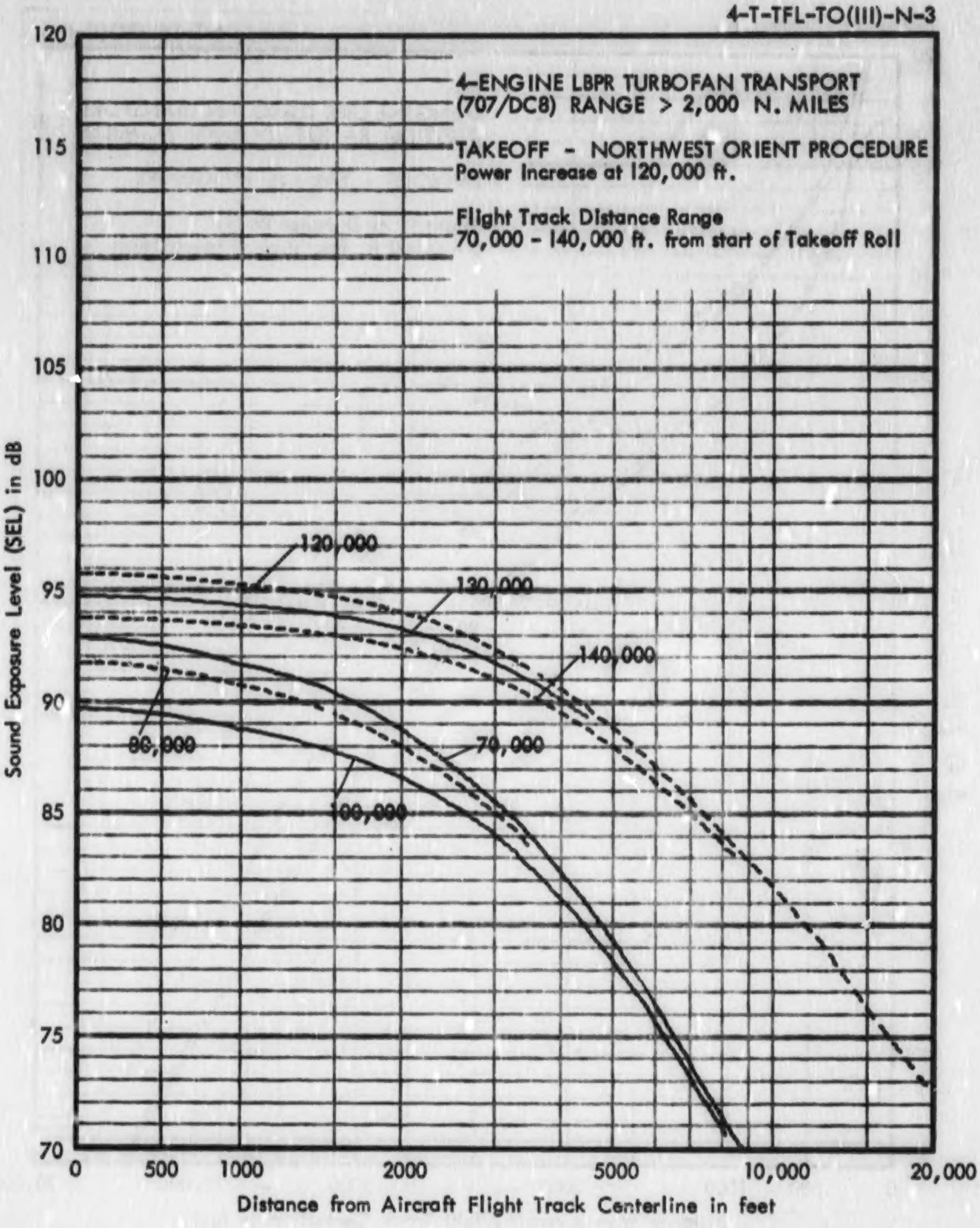
4-T-TFL-TO(III)-N-1



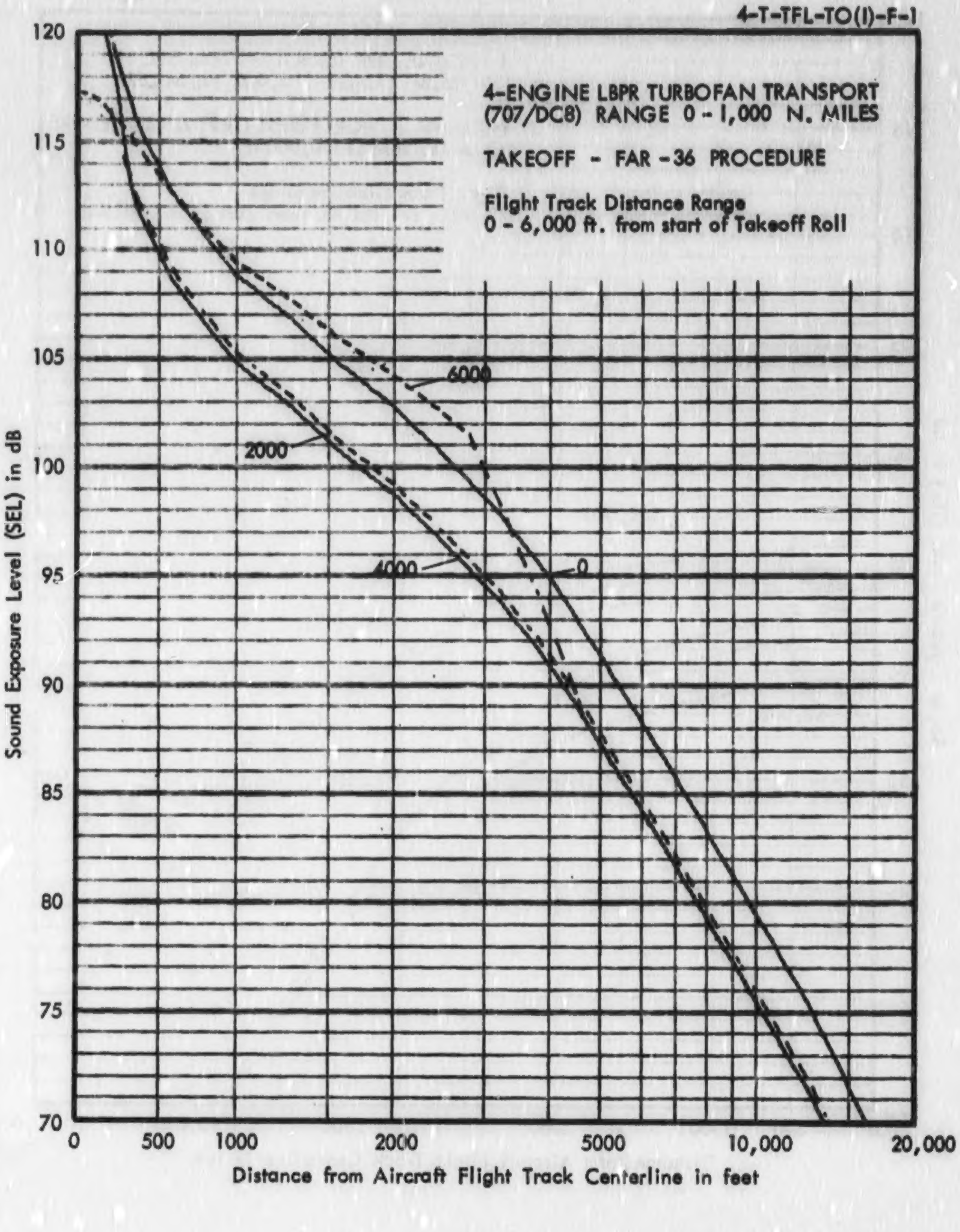
4-T-TFL-TO(III)-N-2

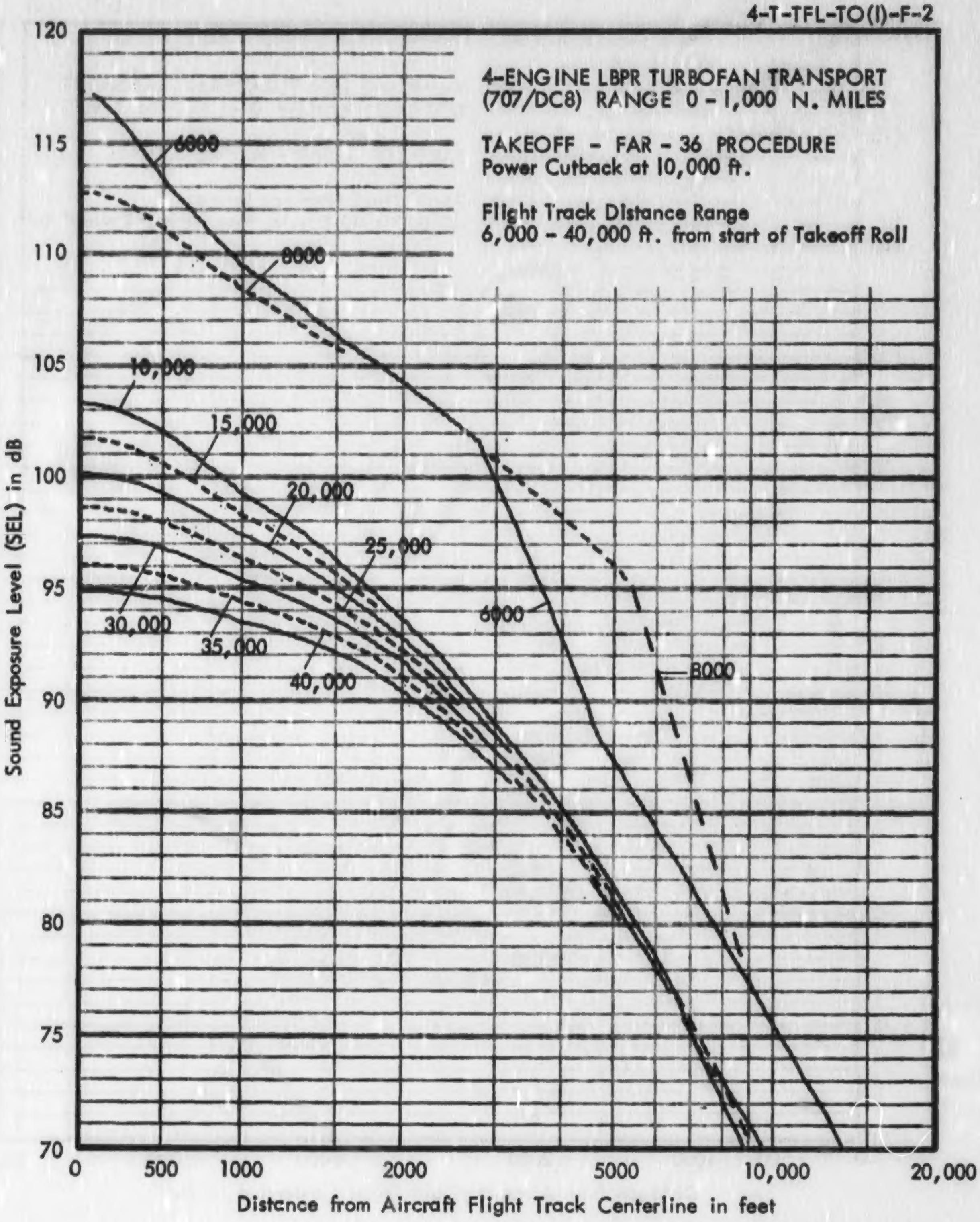


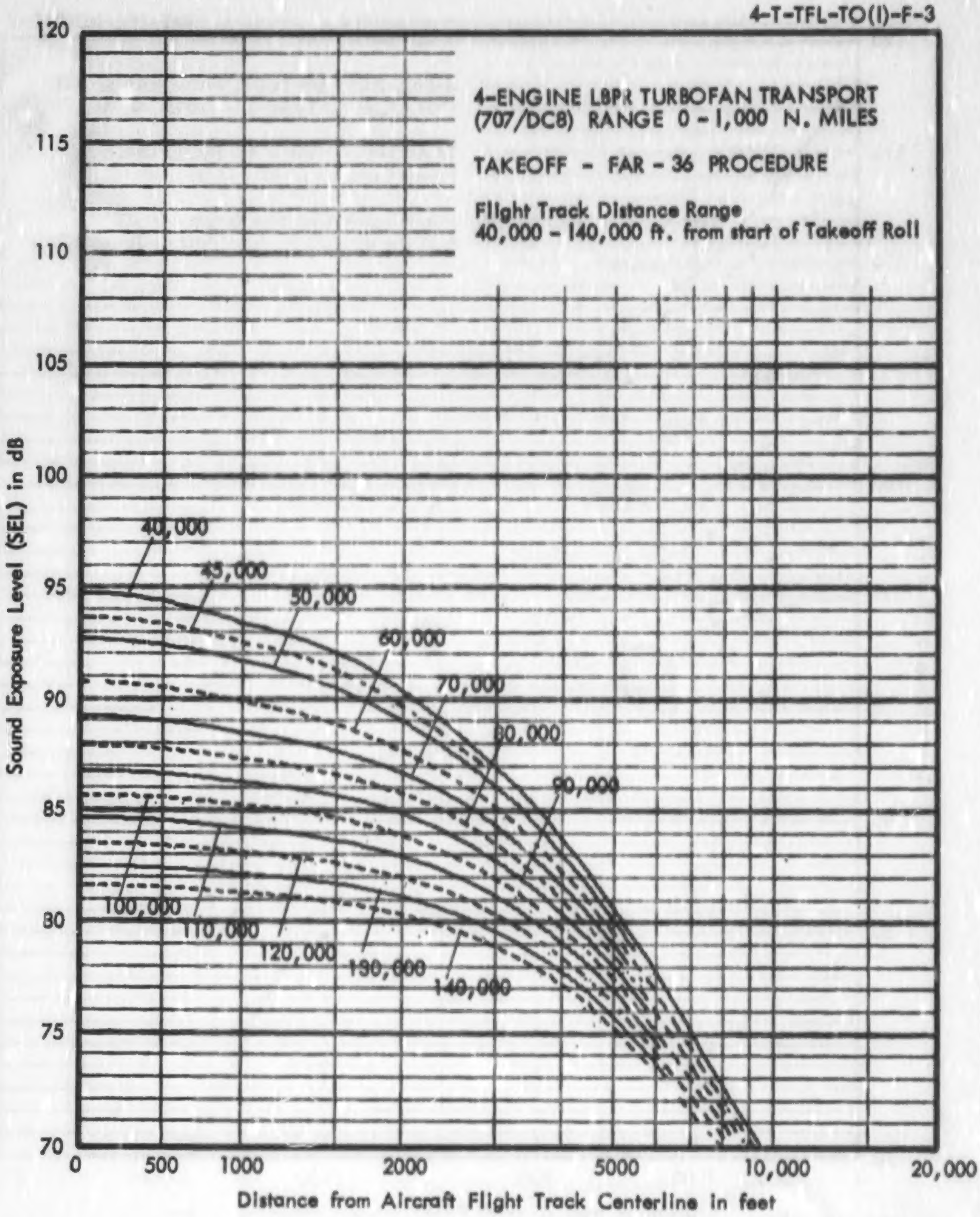
4-T-TFL-TO(III)-N-3



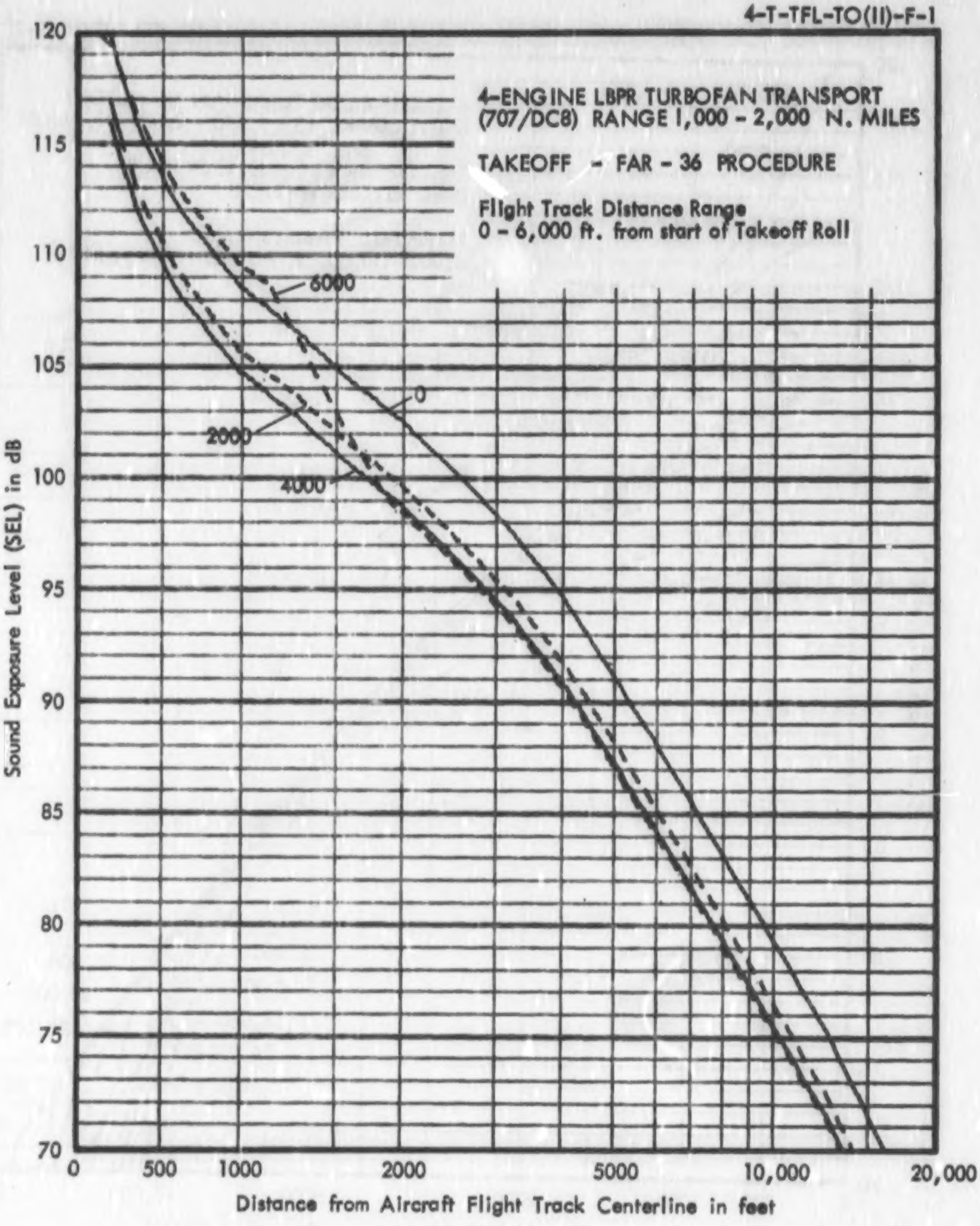
4-T-TFL-TO(I)-F-1

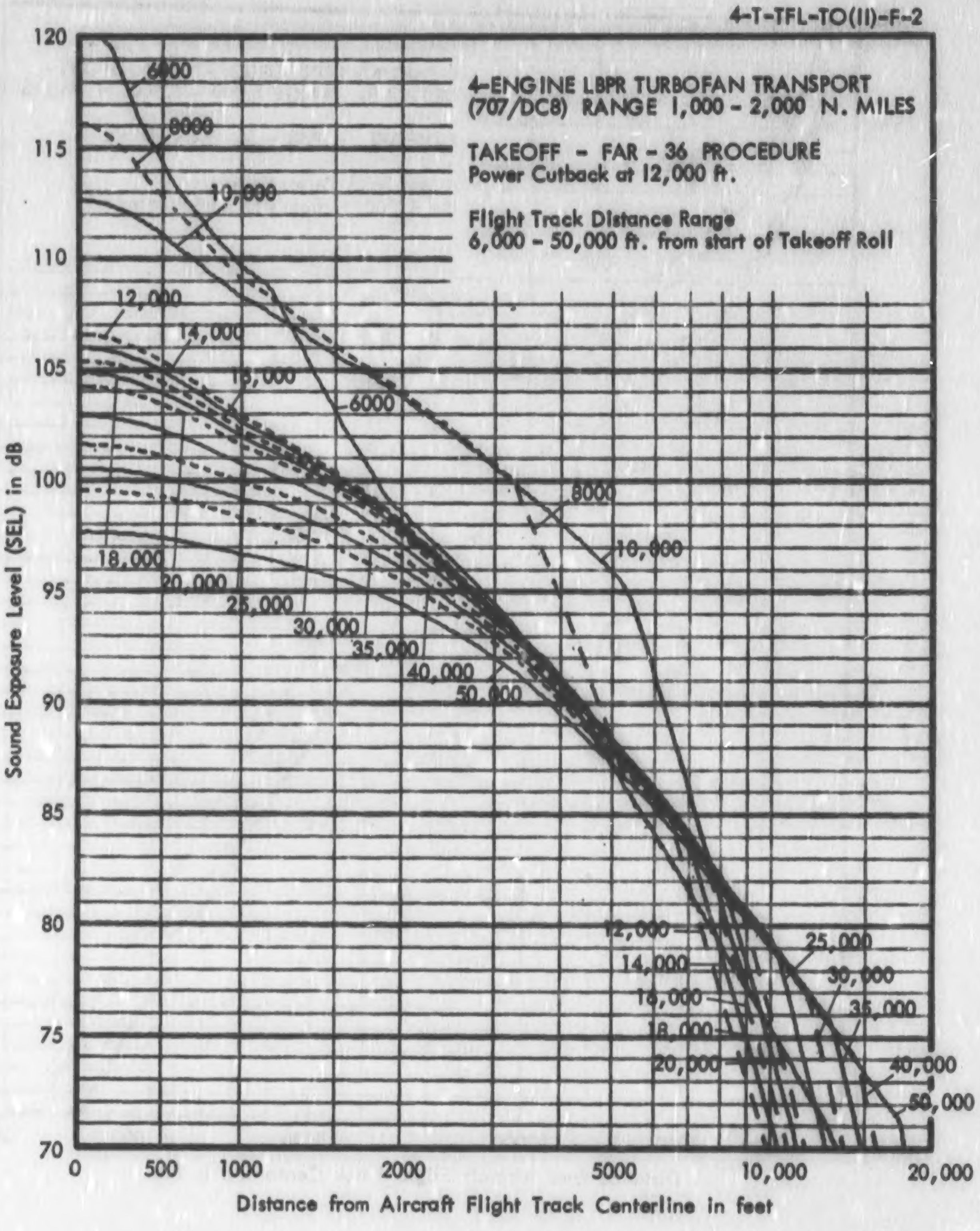

4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
6000
2000
4000
0
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

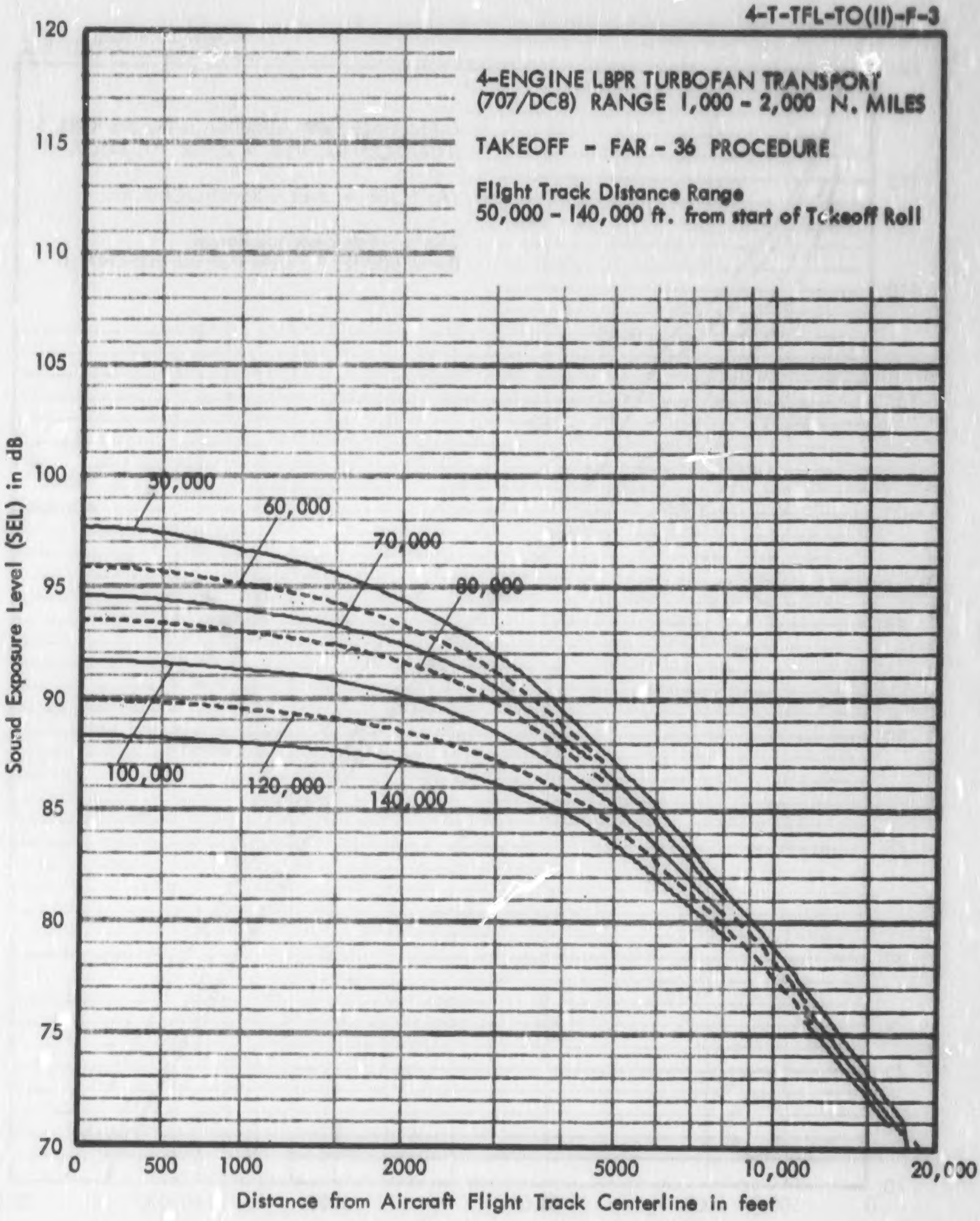

4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Power Cutback at 10,000 ft.
Flight Track Distance Range
6,000 - 40,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
6000
8000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
6000
8000

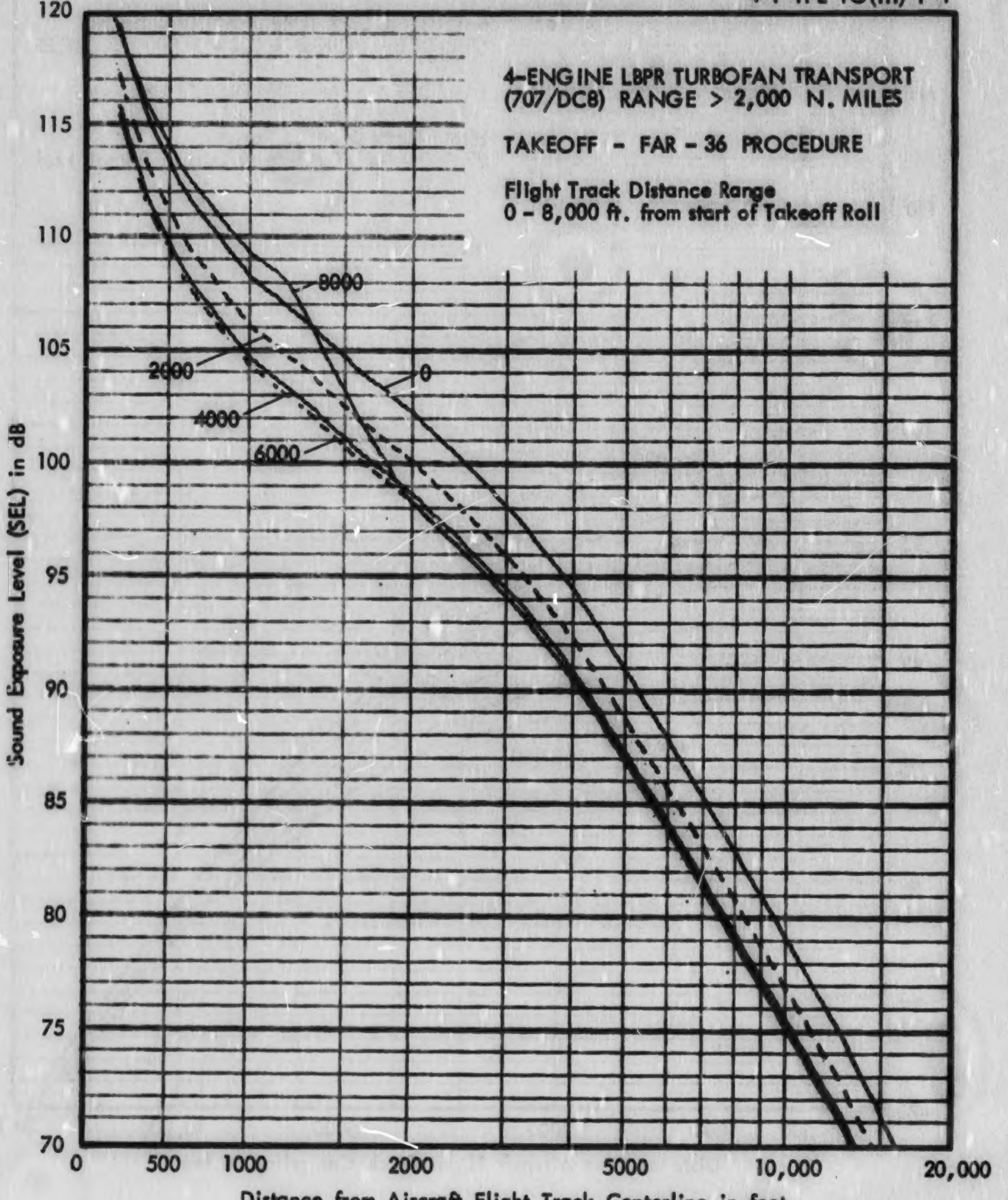

4-ENGINE LBPR TURBOFAN TRANSPORT (707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range 40,000 - 140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
40,000
45,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
130,000
140,000

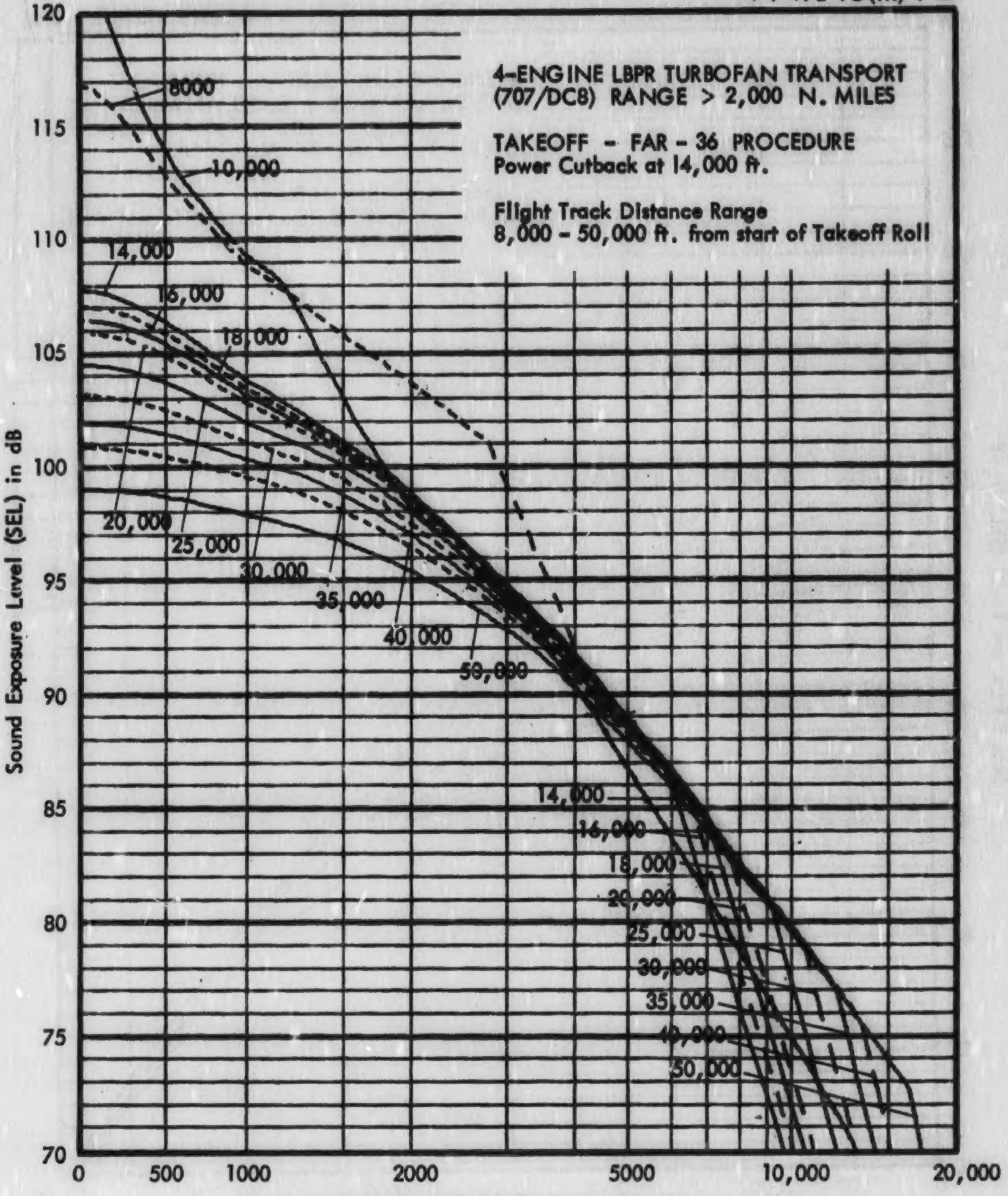
4-T-TFL-TO(II)-F-1



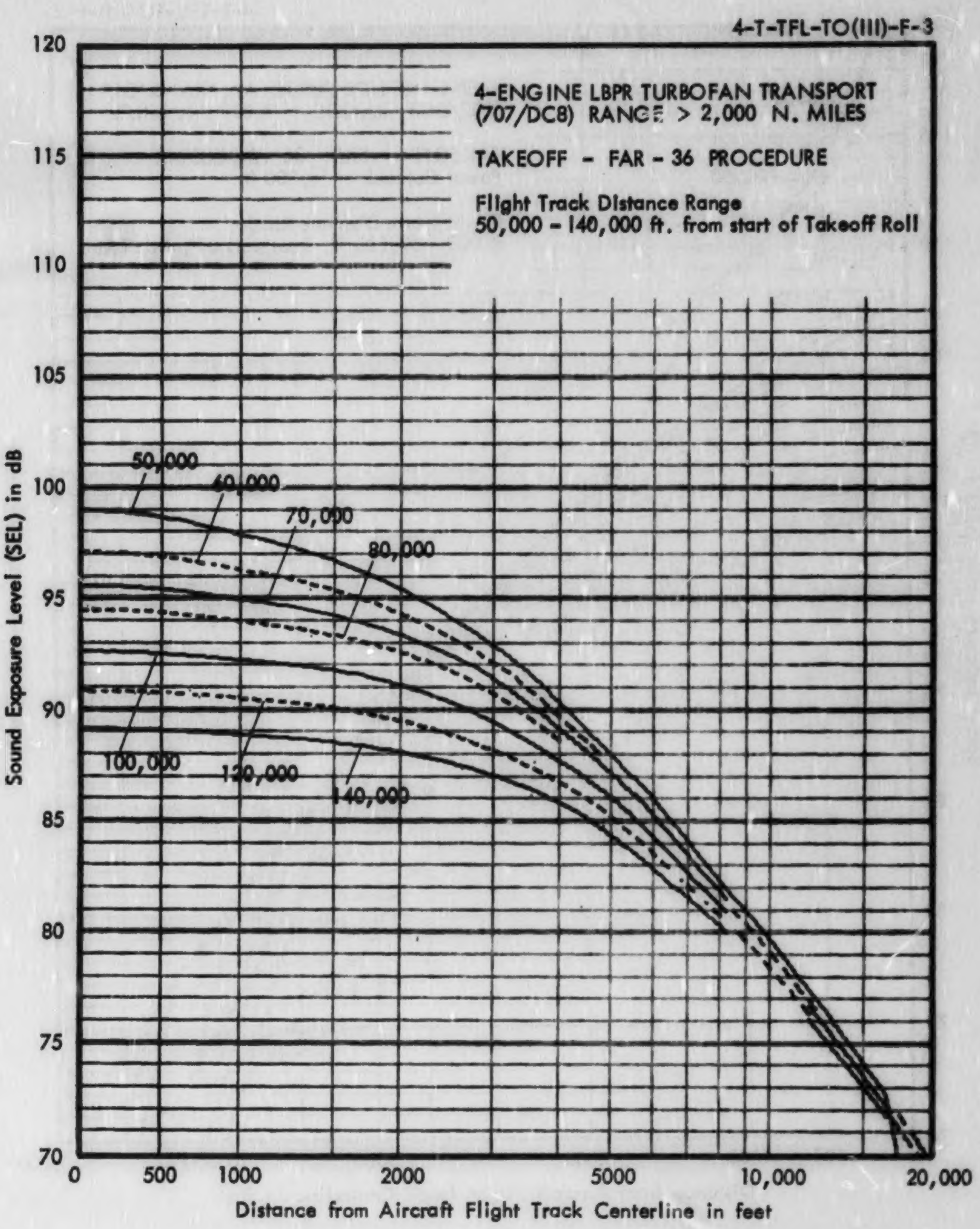

4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Power Cutback at 12,000 ft.
Flight Track Distance Range
6,000 - 50,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000


4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range
50,000 - 140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
50,000
60,000
70,000
80,000
100,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

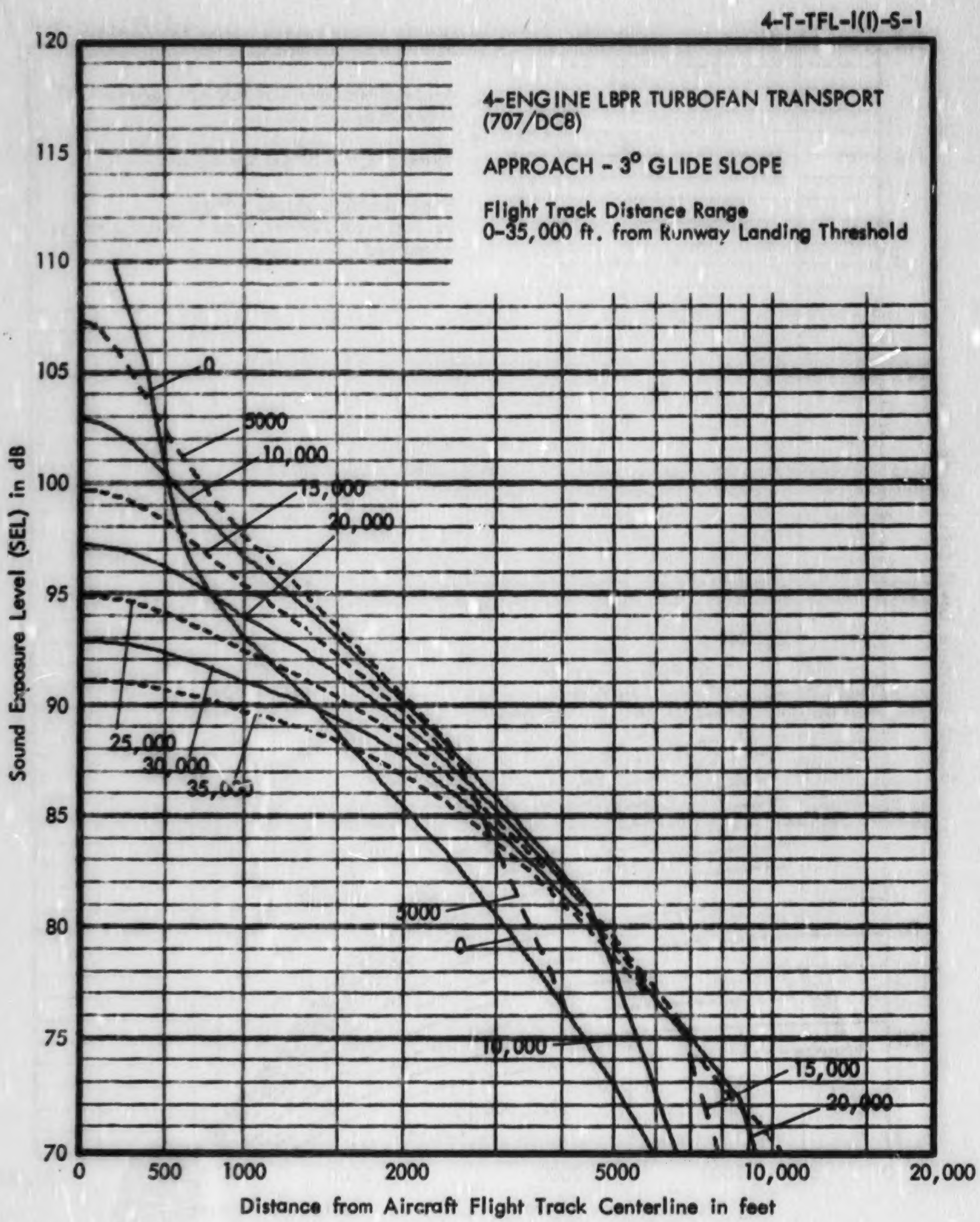

4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE > 2,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range
0 - 8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE LBPR TURBOFAN TRANSPORT
(707/DC8) RANGE > 2,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Power Cutback at 14,000 ft.
Flight Track Distance Range
8,000 - 50,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
8000
10,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000

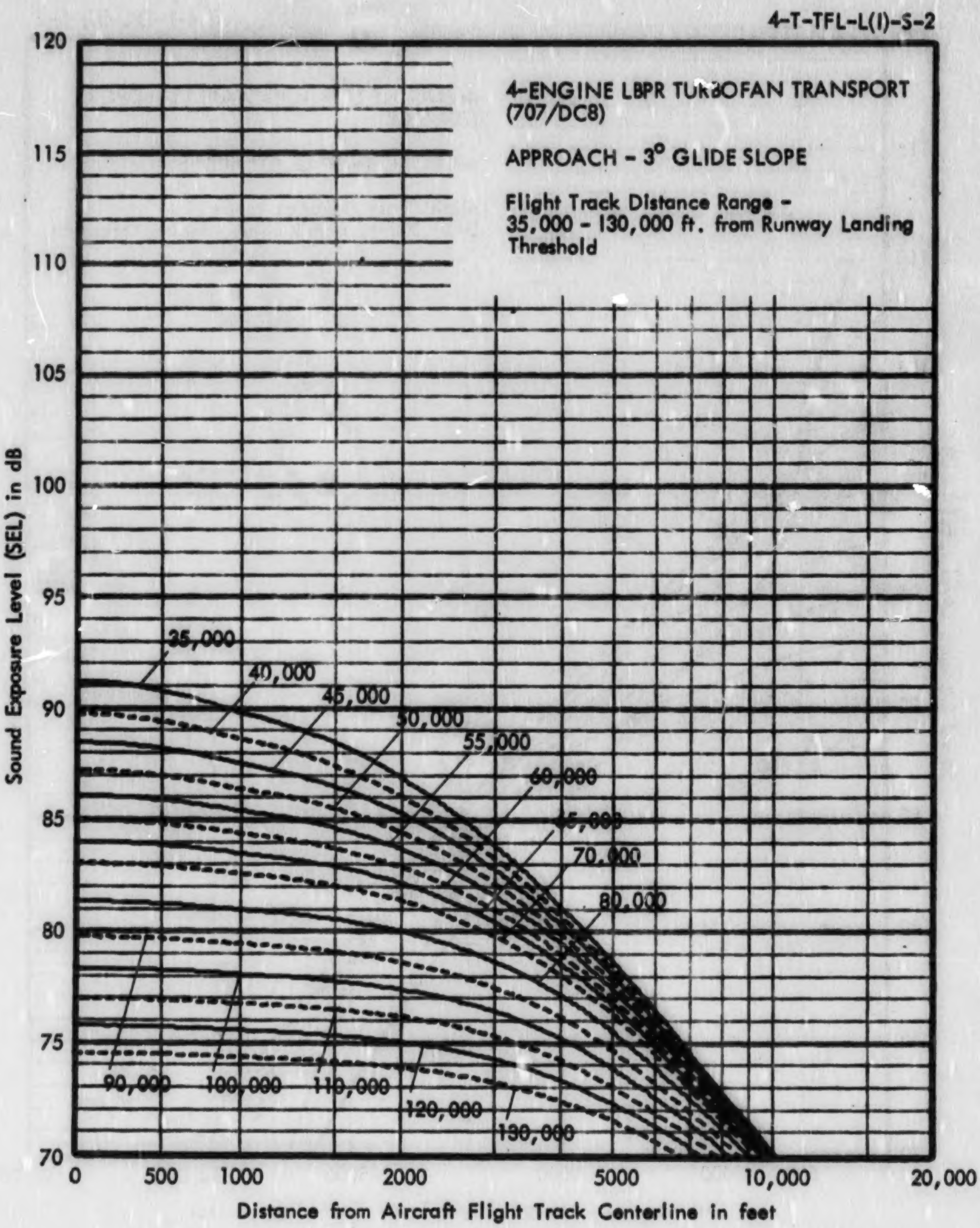
4-T-TFL-TO(III)-F-3



4-T-TFL-I(I)-S-1


4-ENGINE LBPR TURBOFAN TRANSPORT (707/DC8)
APPROACH - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
5000
0
10,000
15,000
20,000

4-T-TFL-L(I)-S-2

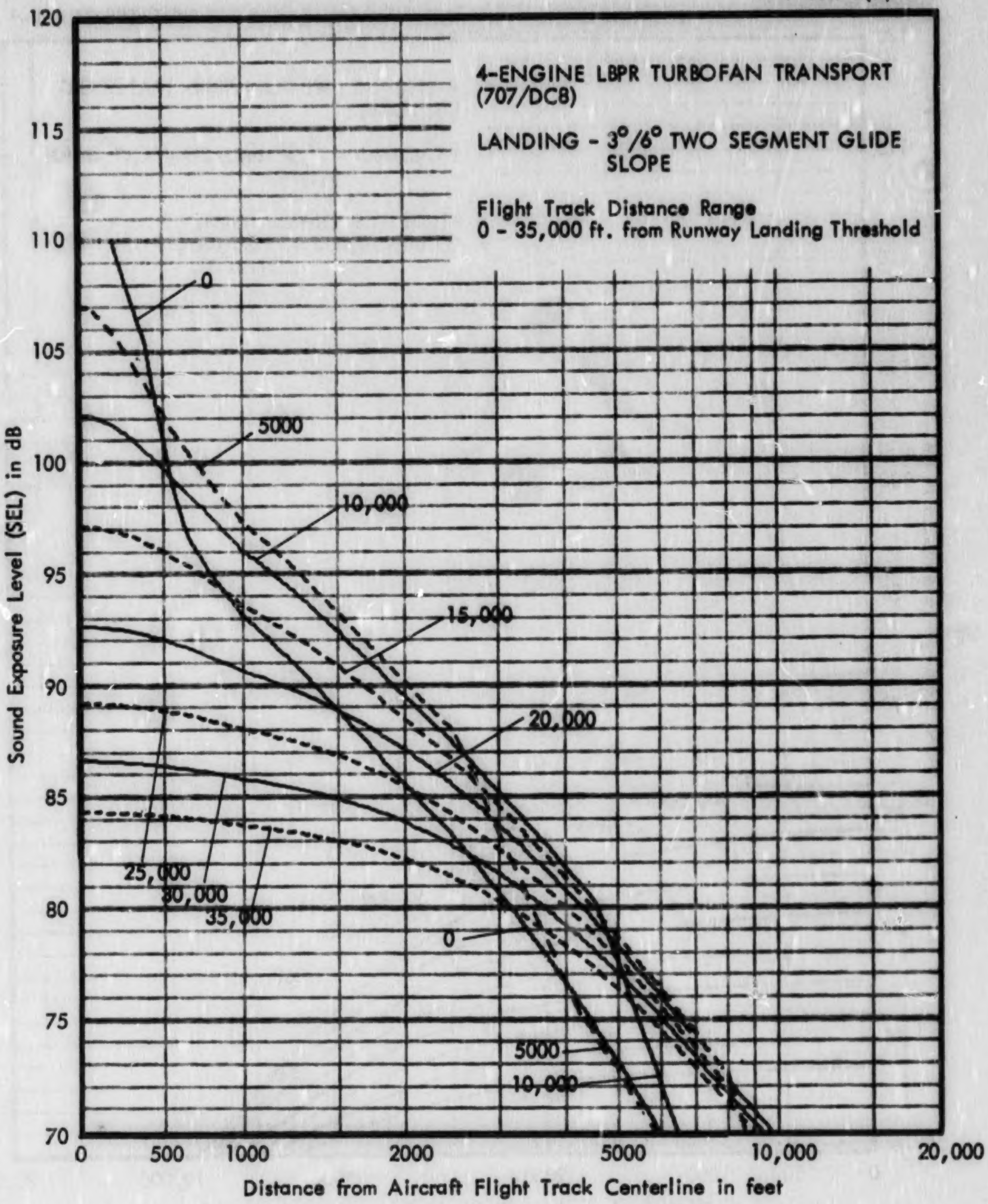


4-ENGINE LBPR TURBOFAN TRANSPORT (707/DC8)

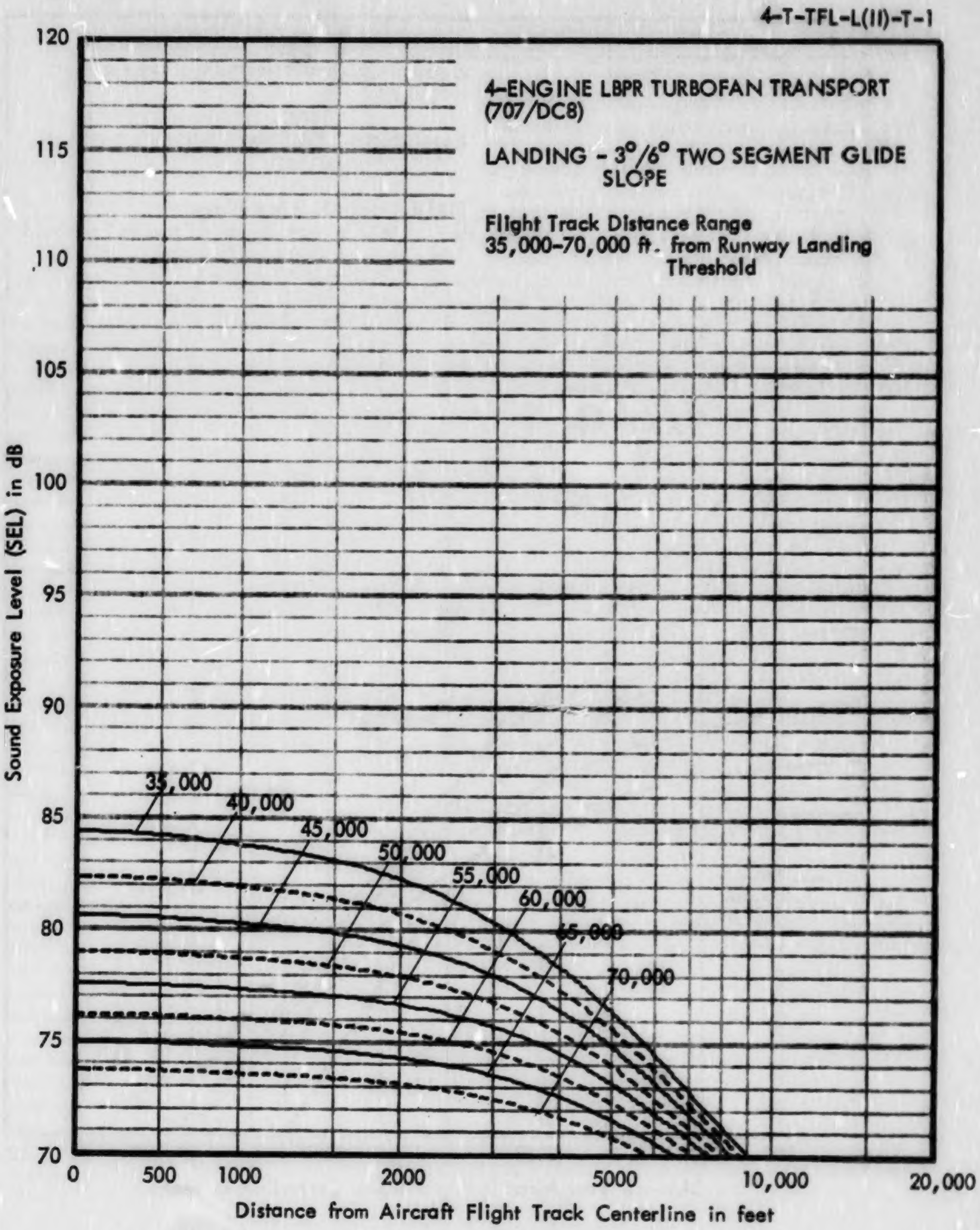
APPROACH – 3° GLIDE SLOPE

Flight Track Distance Range – 35,000 – 130,000 ft. from Runway Landing Threshold

4-T-TFL-L(II)-T-1


4-ENGINE LBPR TURBOFAN TRANSPORT (707/DC8)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range
0 - 35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5000
10,000

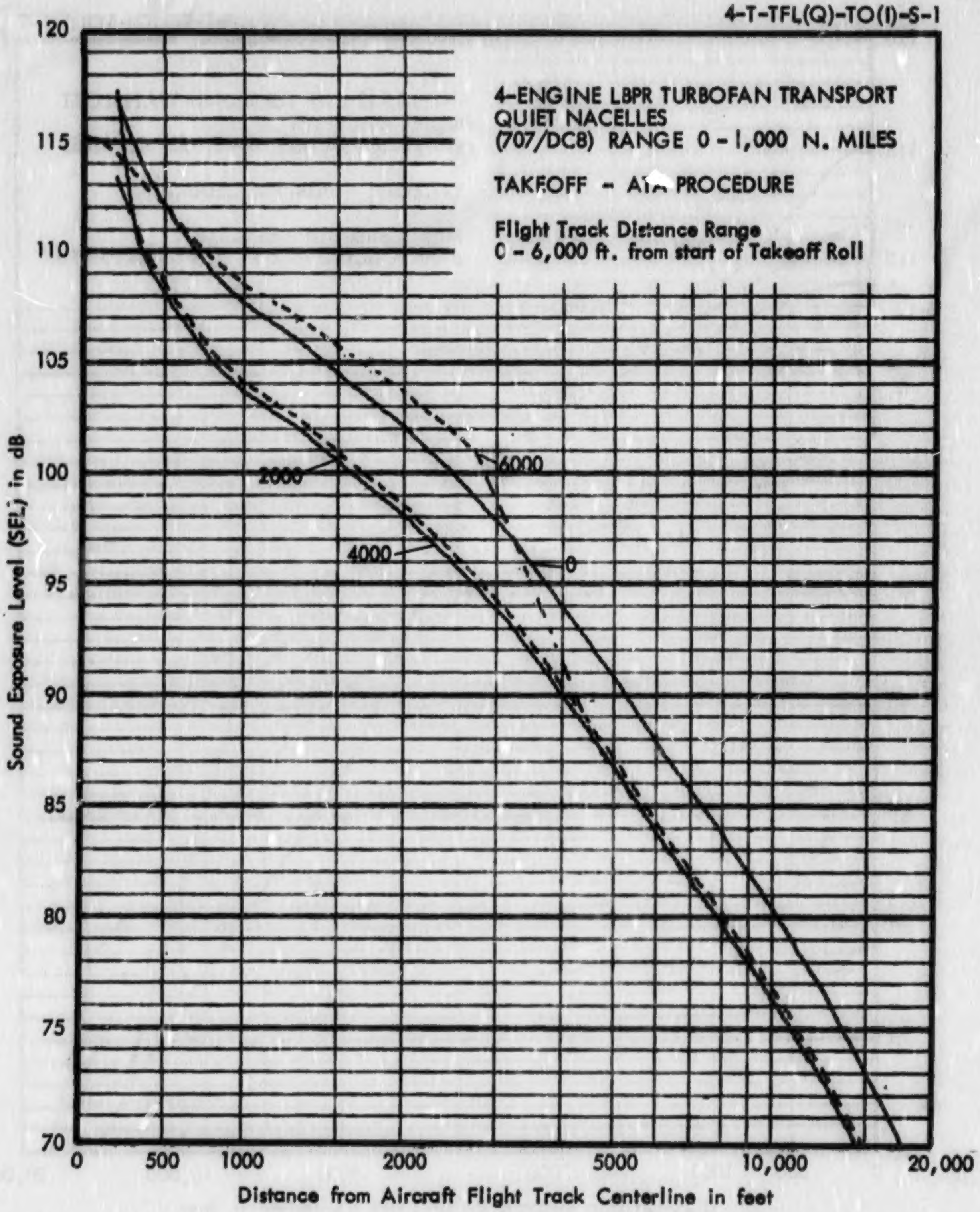
4-T-TFL-L(II)-T-1



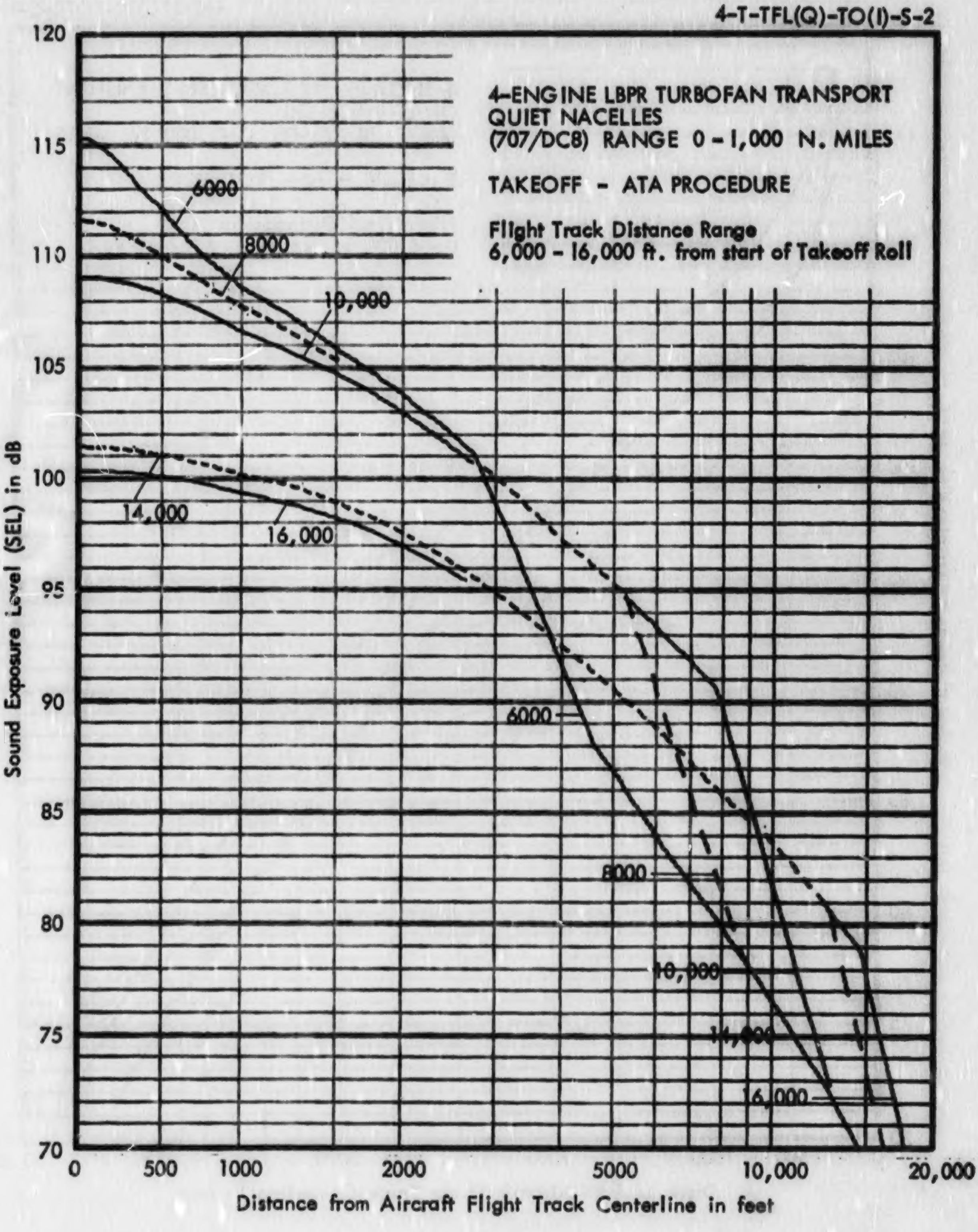
4-ENGINE LBPR TURBOFAN TRANSPORT (707/DC8)

LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE

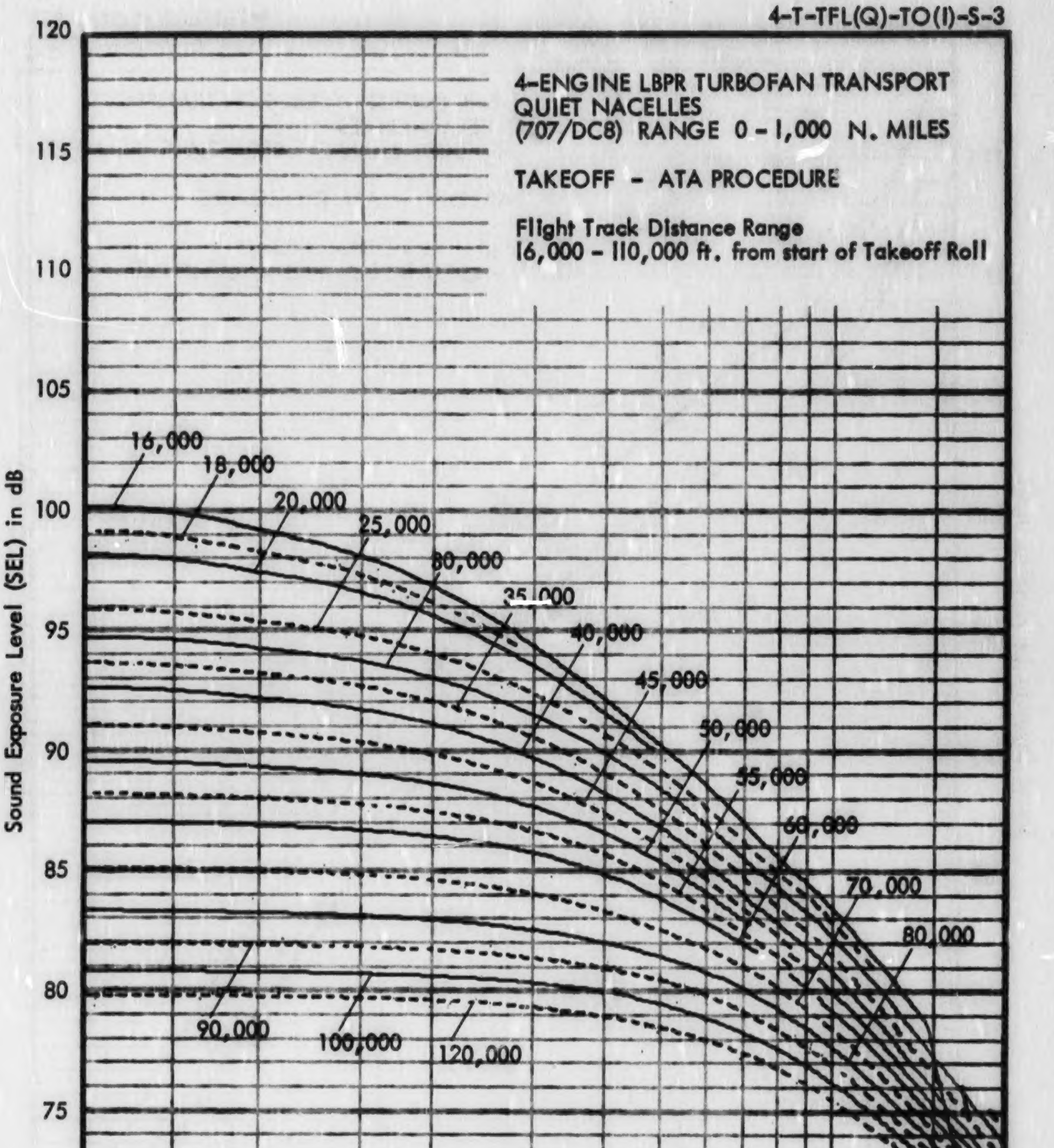
Flight Track Distance Range 35,000-70,000 ft. from Runway Landing Threshold

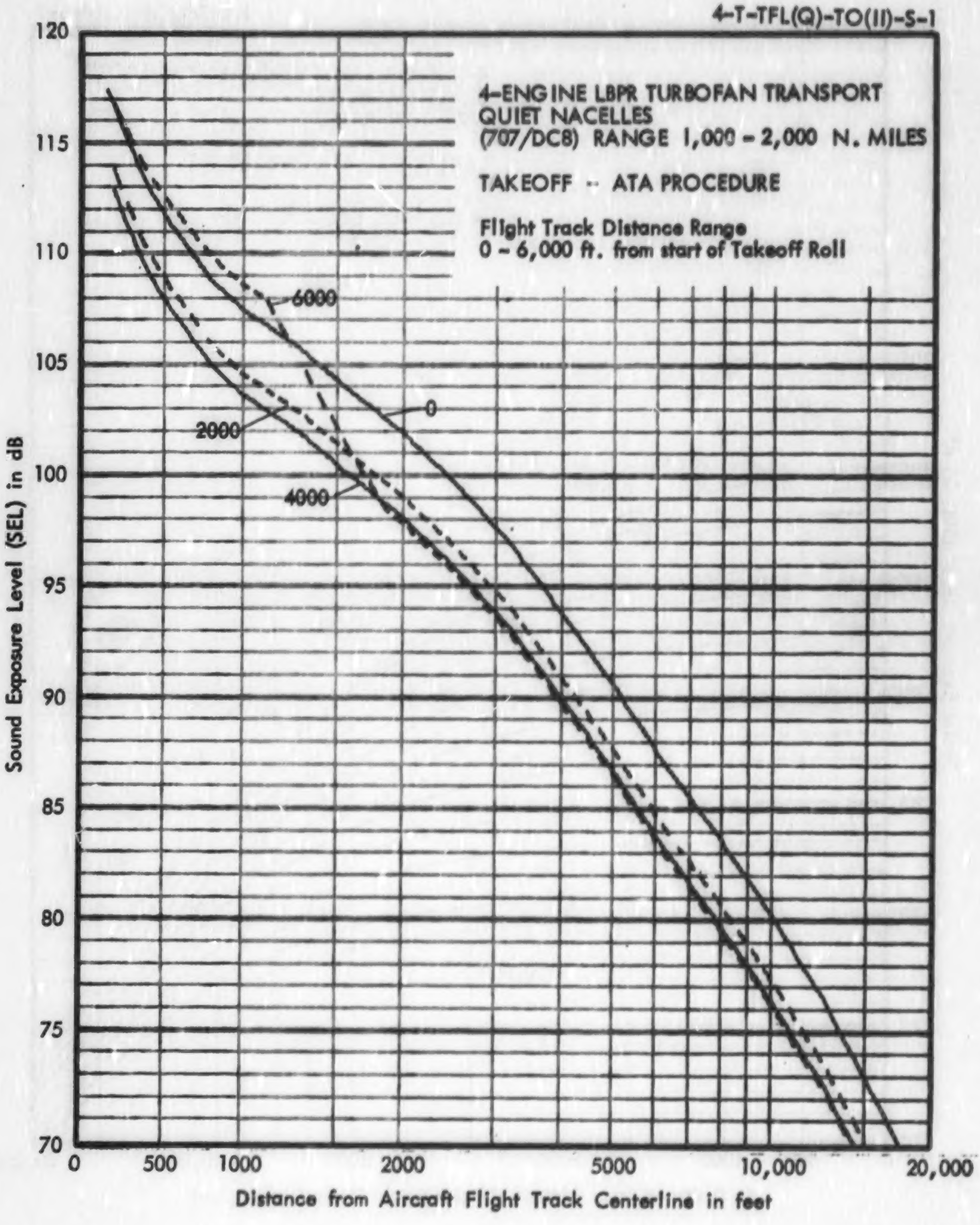

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - ATA PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
6000
2000
4000
0

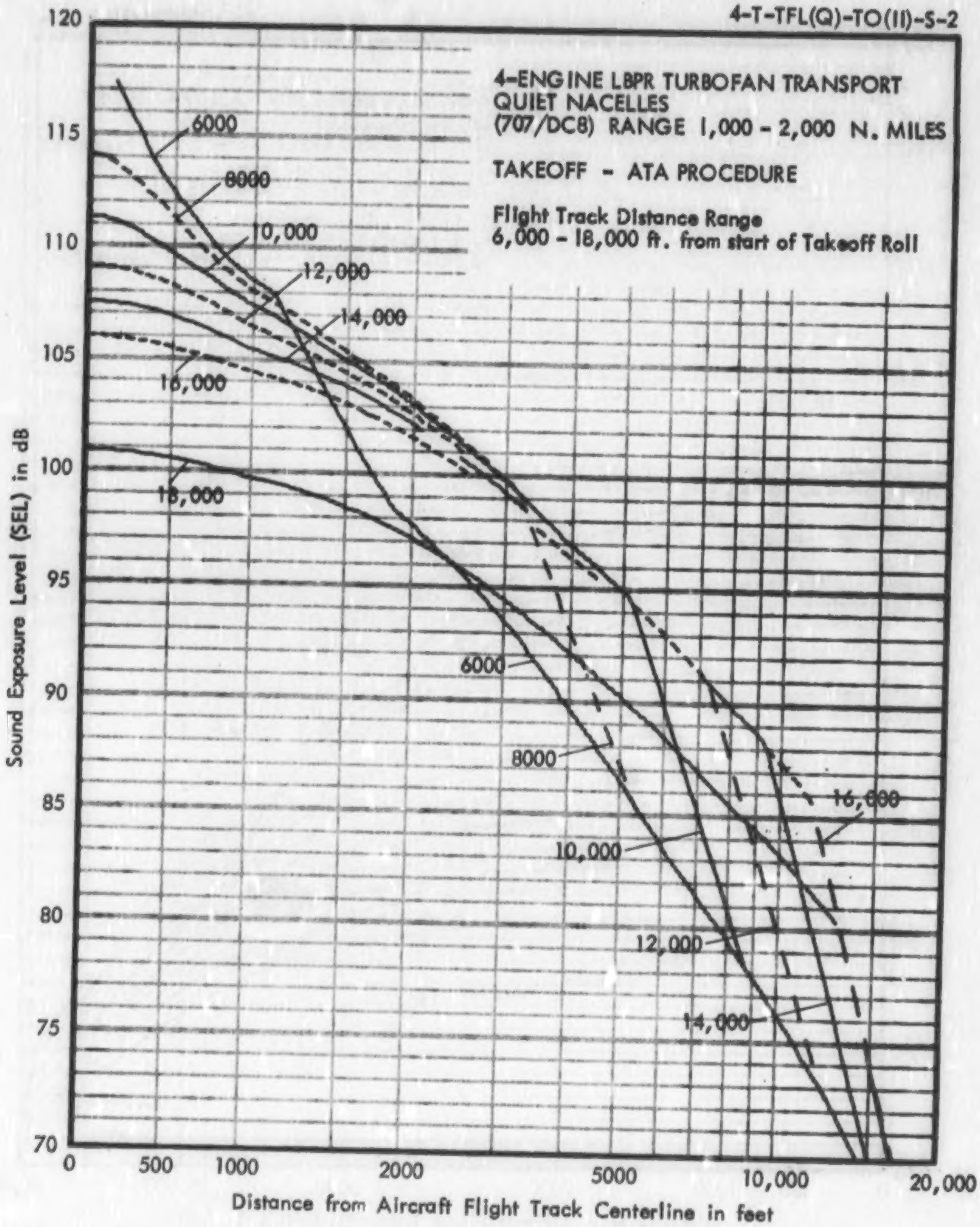
4-T-TFL(Q)-TO(I)-S-2



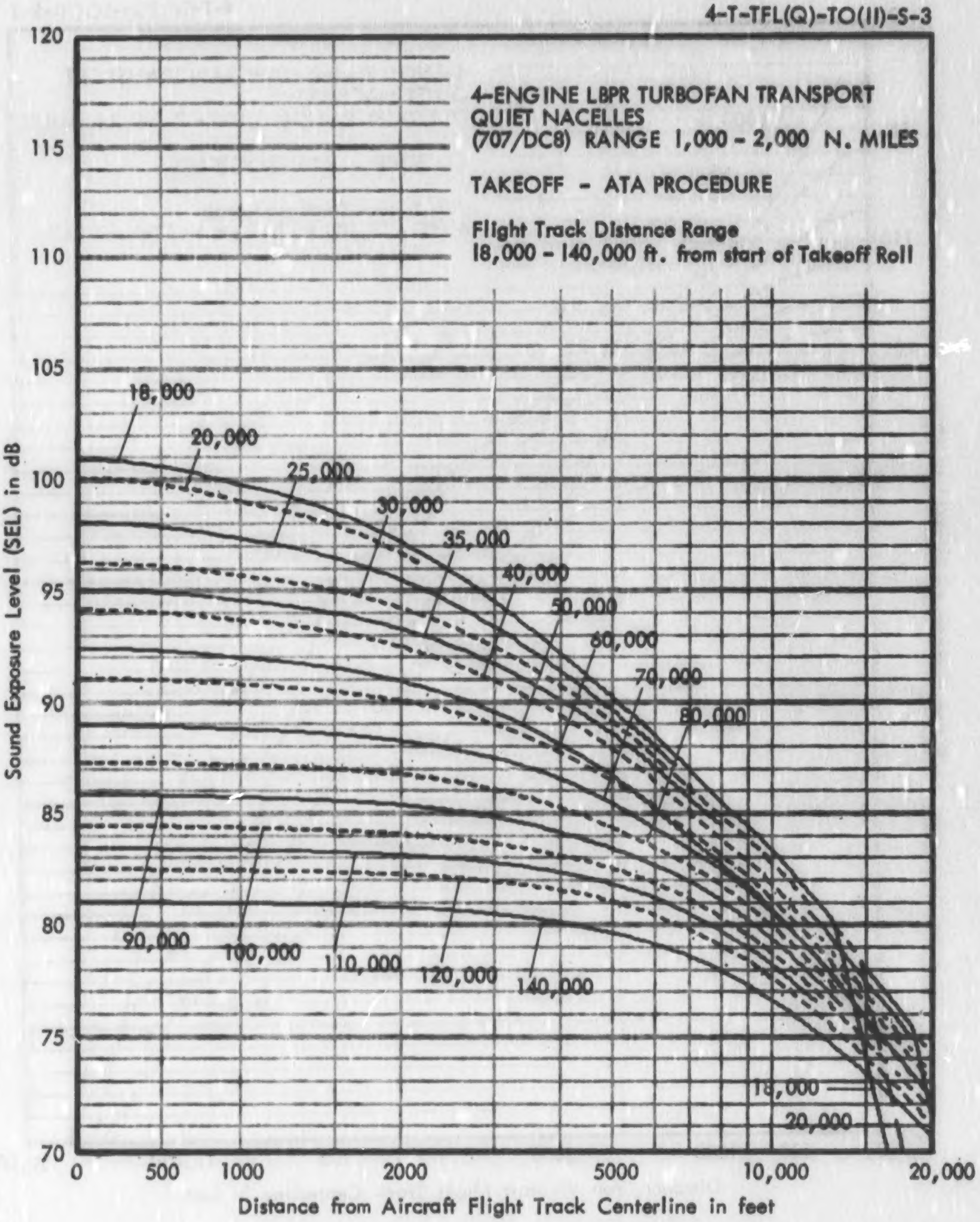
4-T-TFL(Q)-TO(I)-S-3



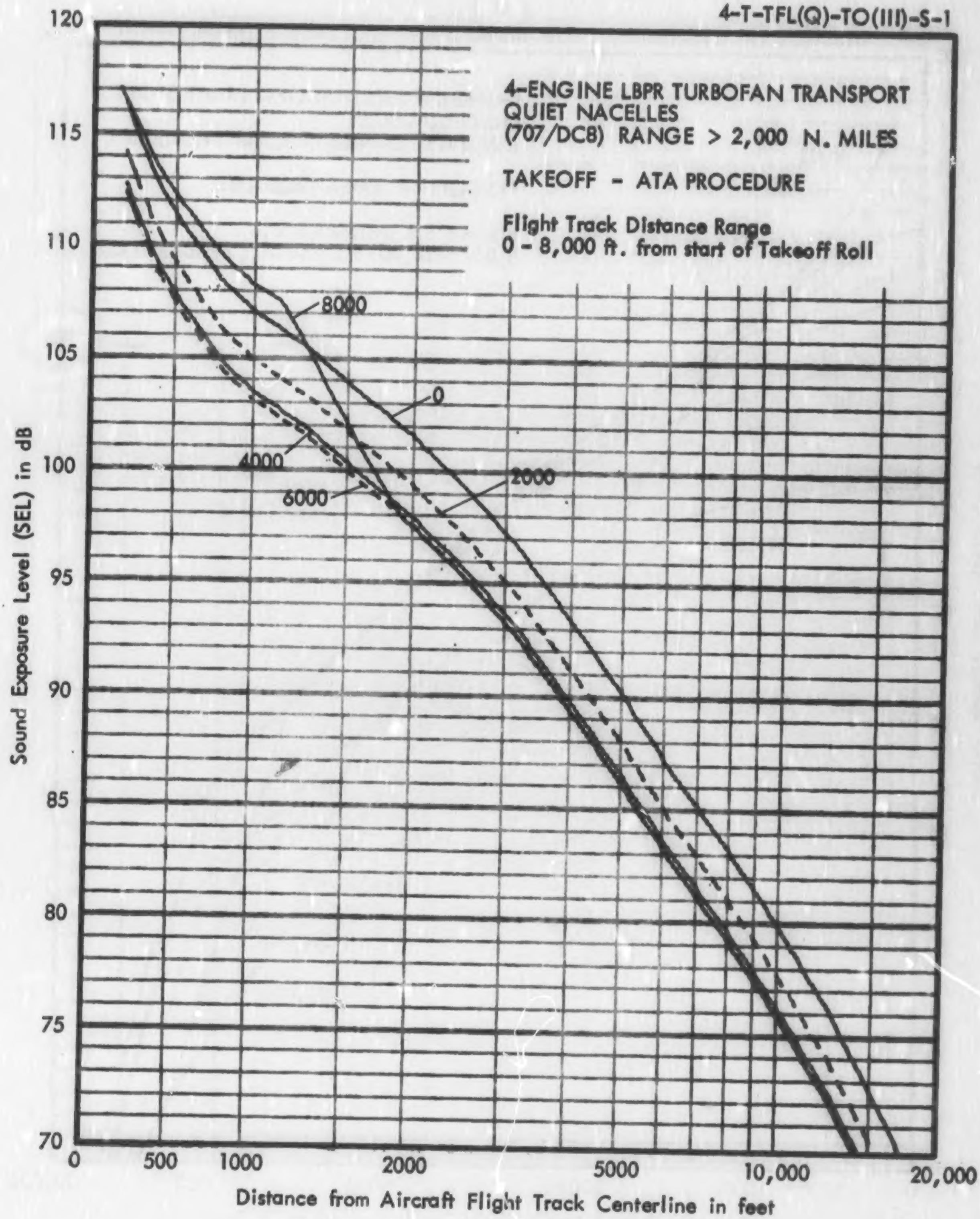

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF -- ATA PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
6000
0
2000
4000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF - ATA PROCEDURE
Flight Track Distance Range
6,000 - 18,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
6000
8000
10,000
12,000
14,000
16,000
18,000
6000
8000
10,000
12,000
14,000
16,000

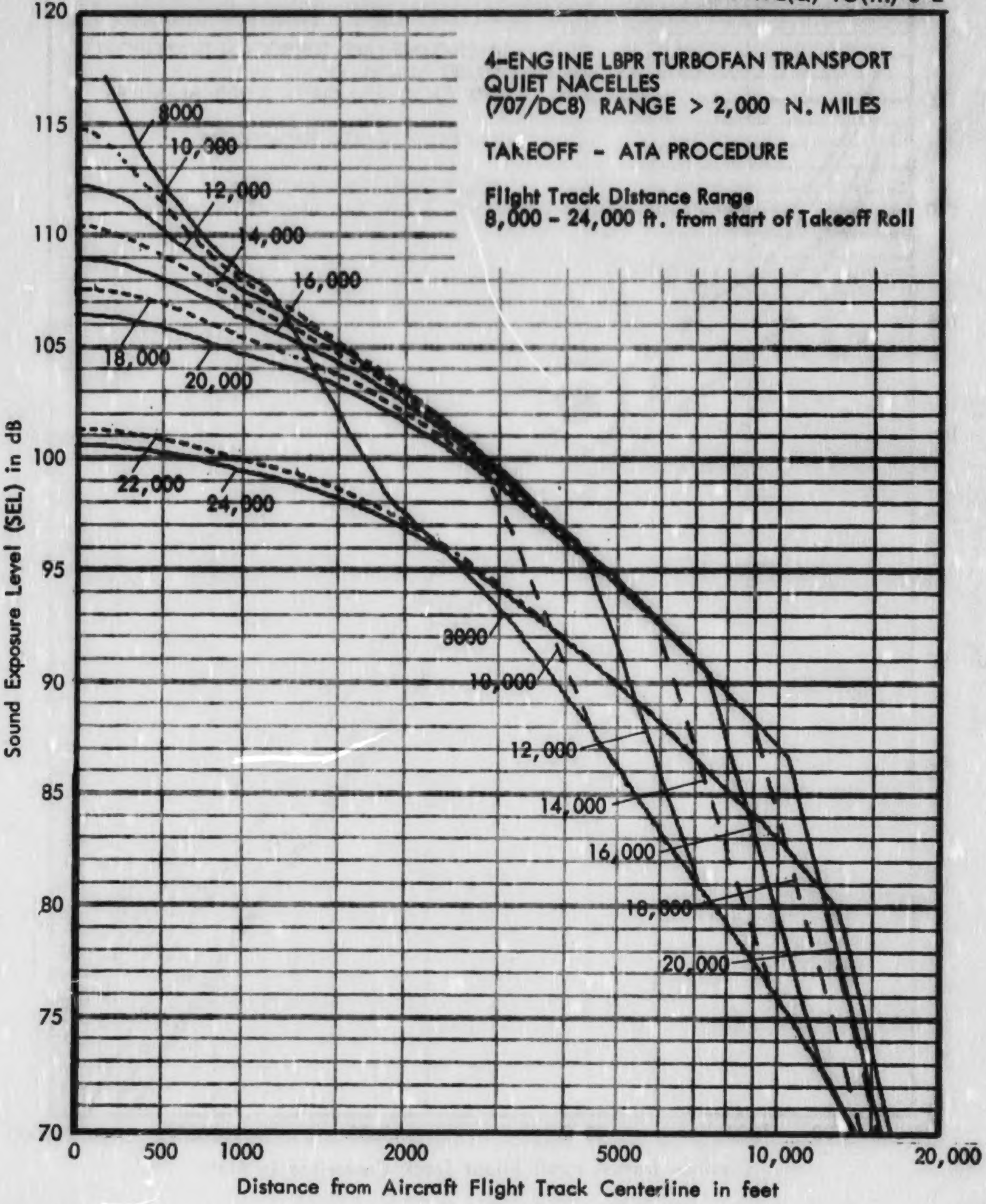
4-T-TFL(Q)-TO(II)-S-3



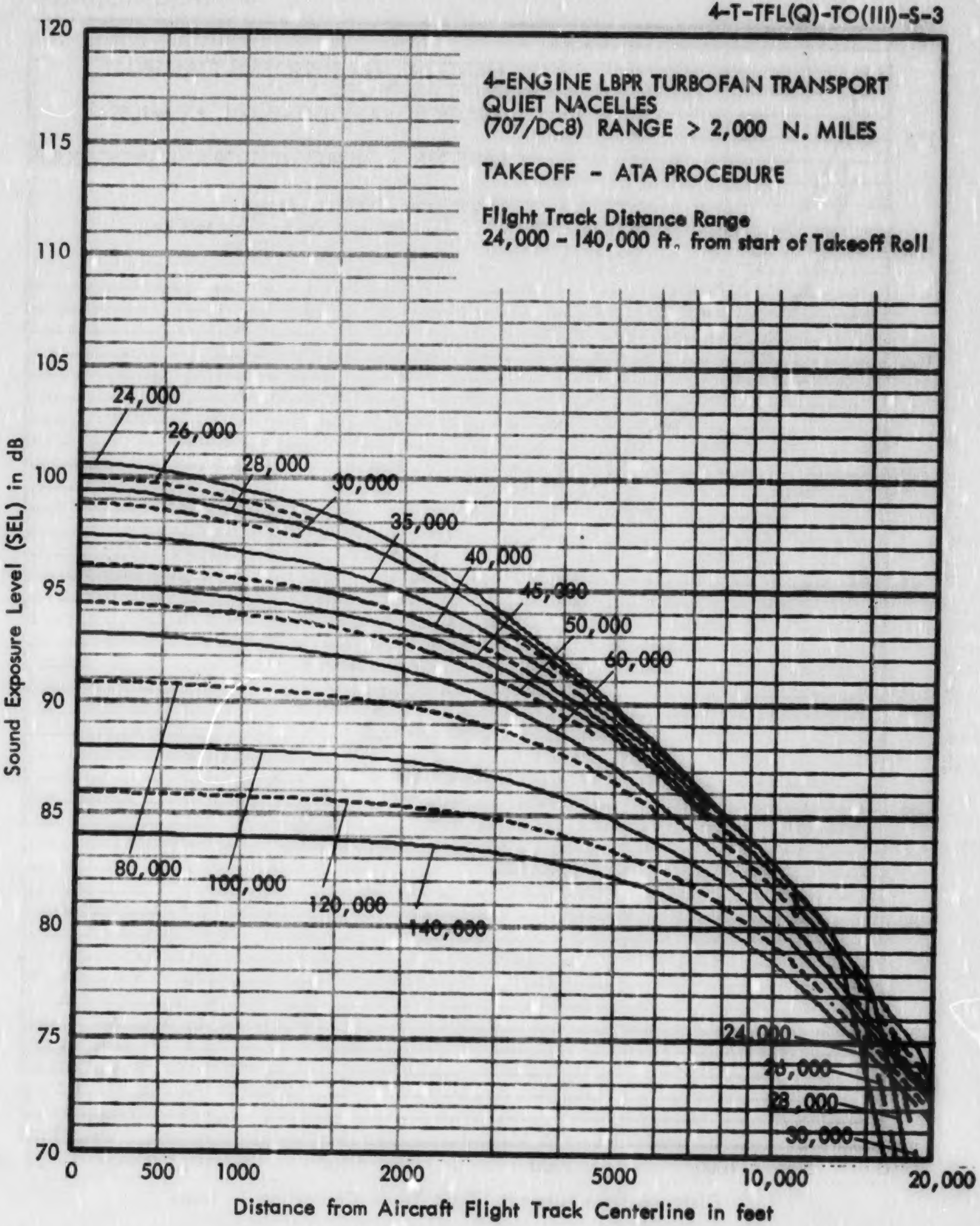
4-T-TFL(Q)-TO(III)-S-1

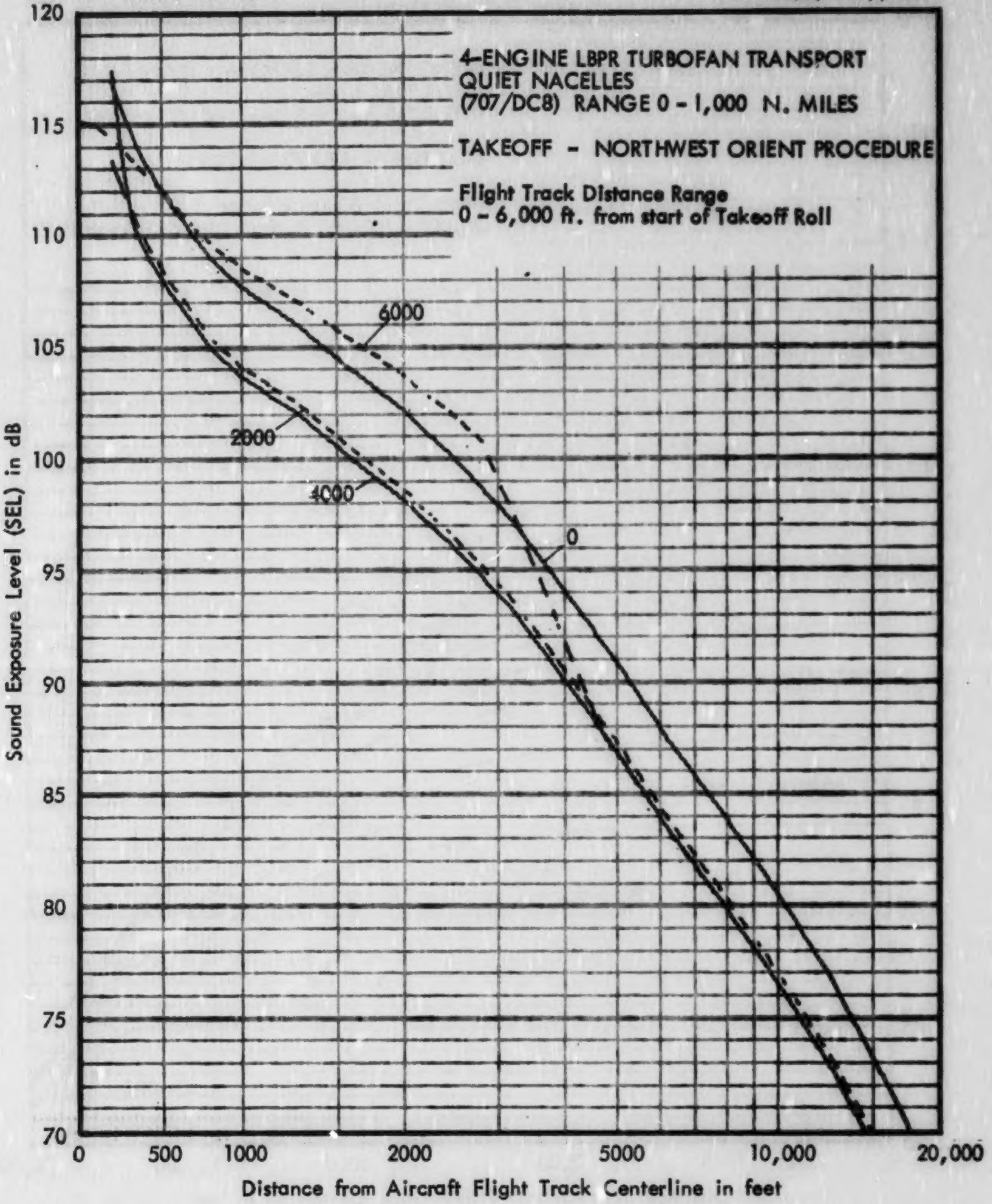


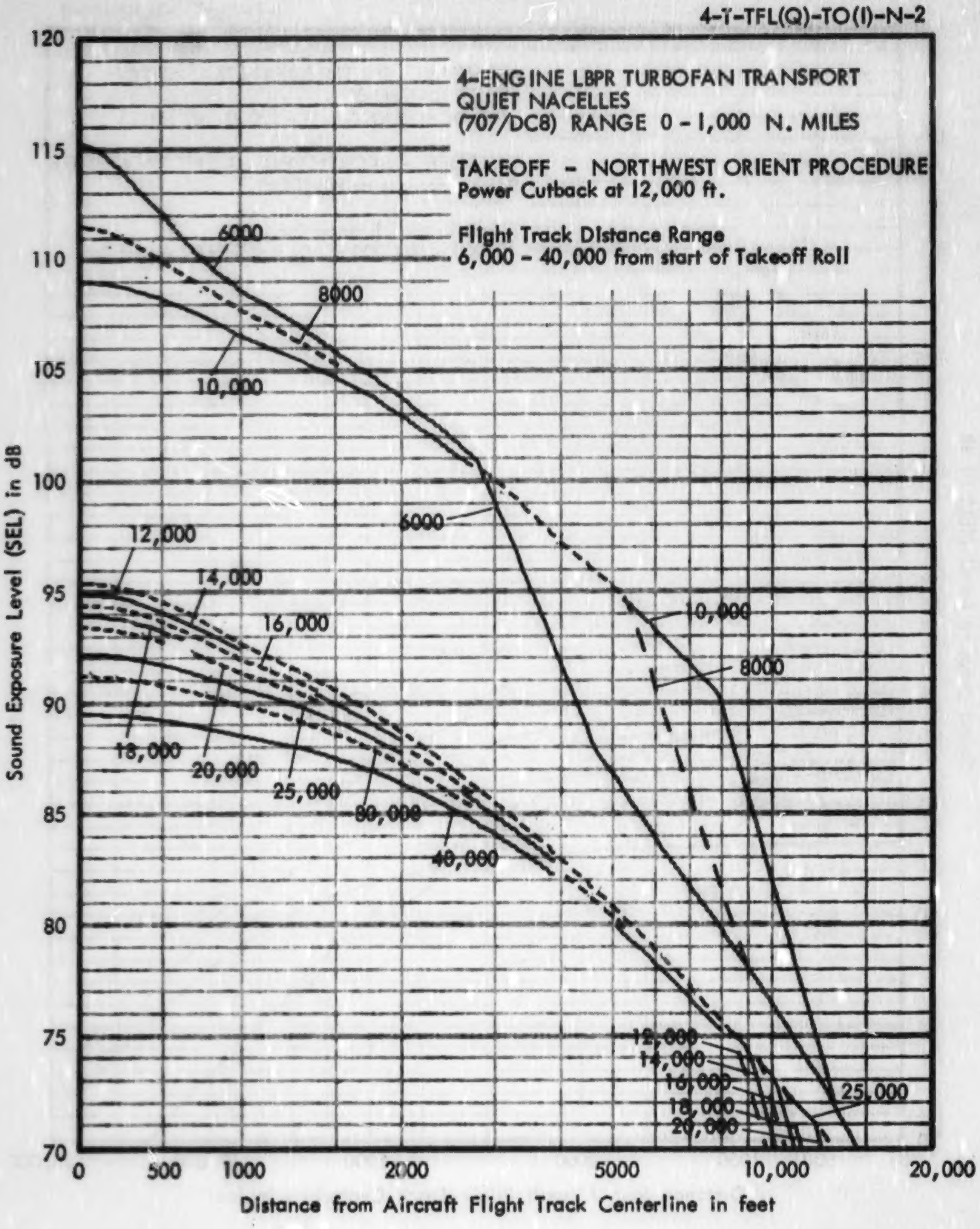
4-T-TFL(Q)-TO(III)-S-2



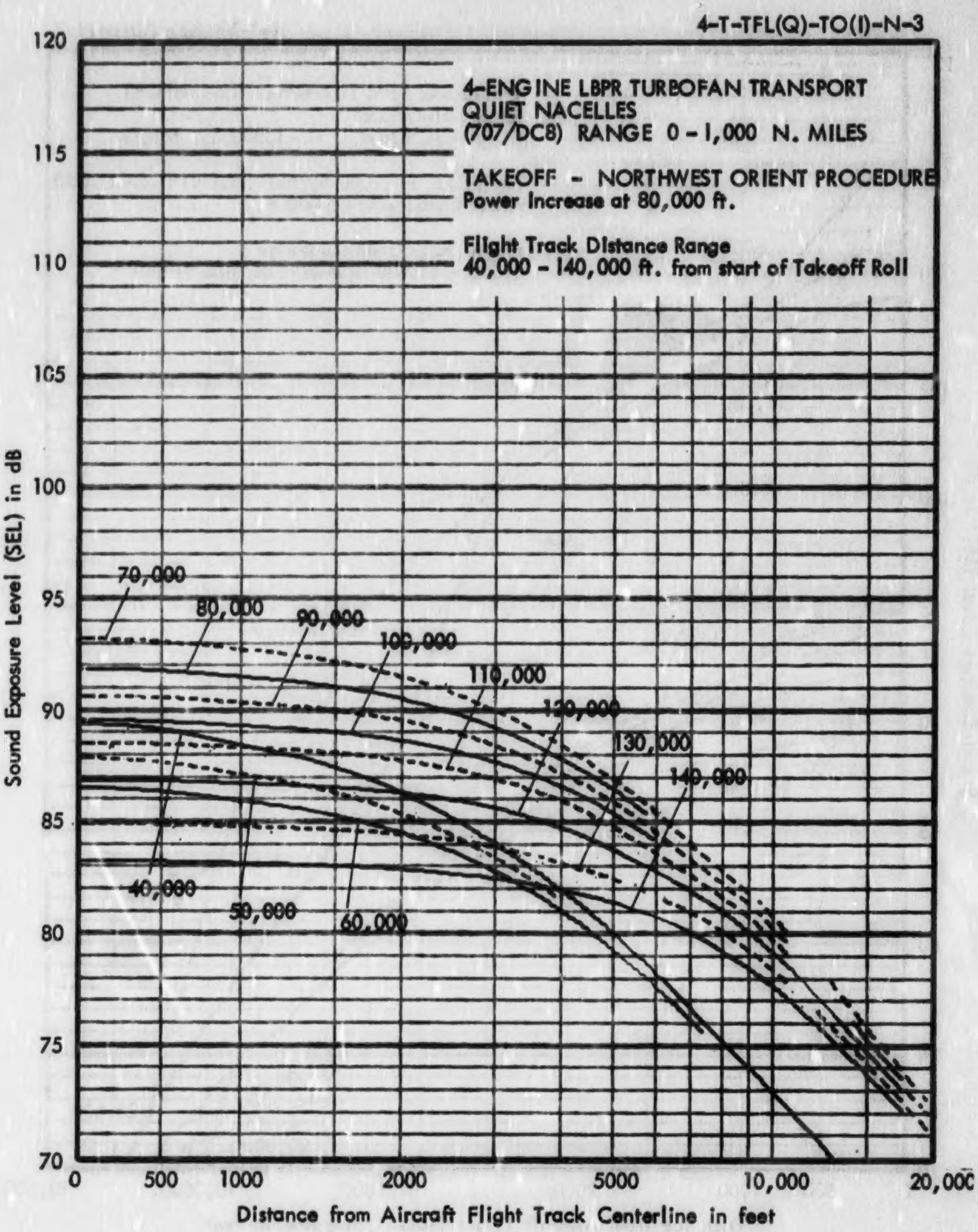
4-T-TFL(Q)-TO(III)-S-3

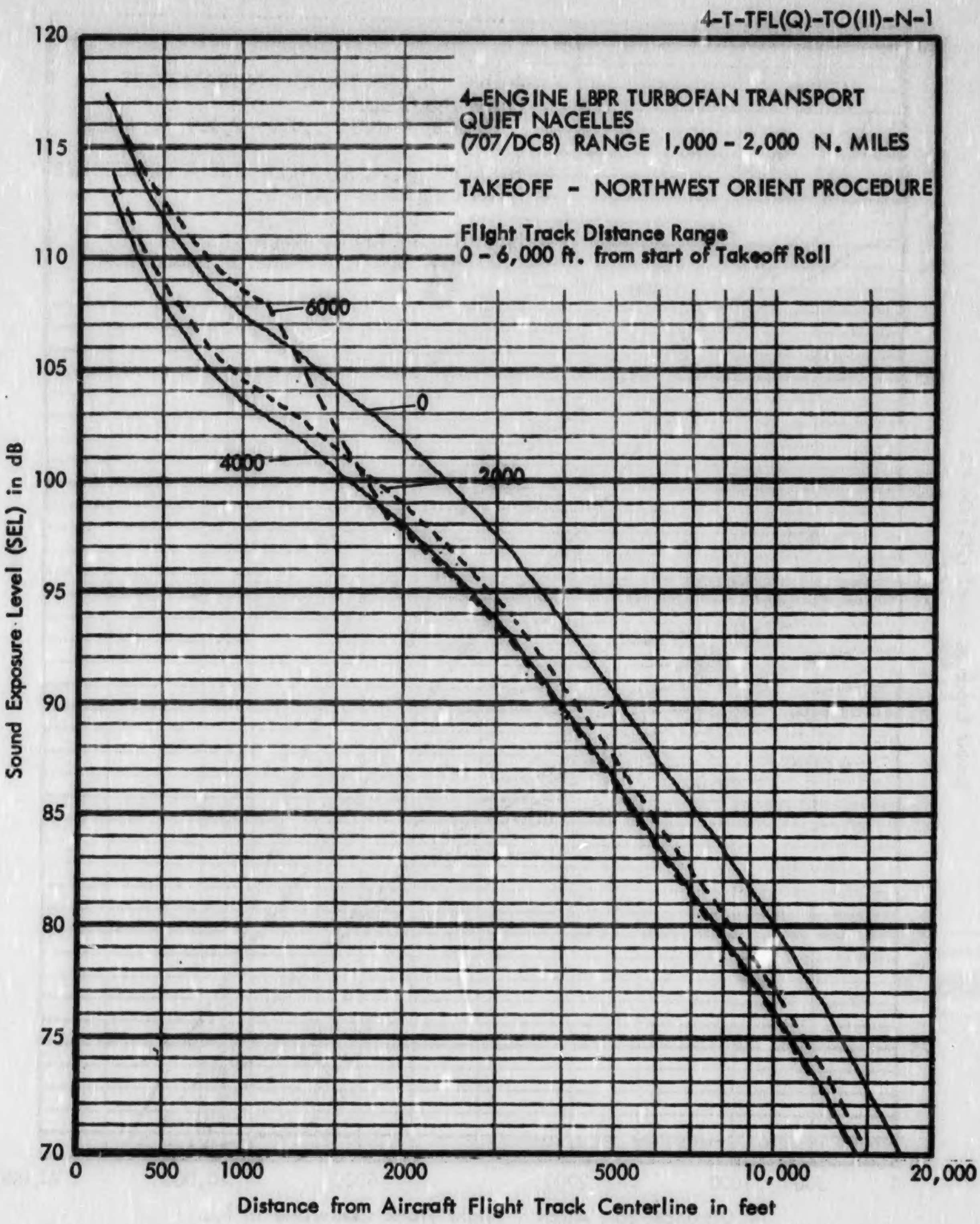


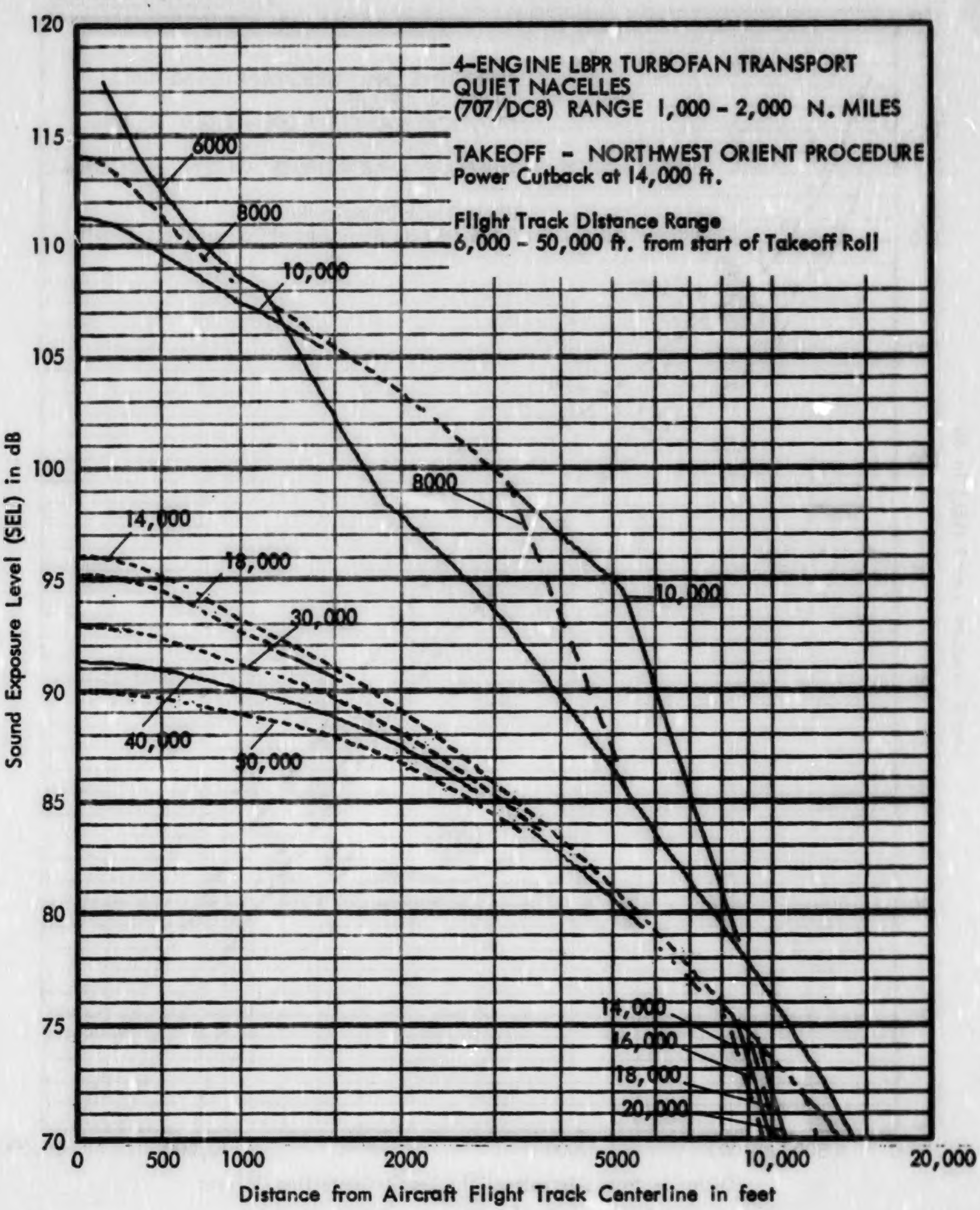

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
6000
2000
4000
0
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 12,000 ft.
Flight Track Distance Range
6,000 - 40,000 from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
6000
8000
10,000
6000
10,000
8000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
40,000
12,000
14,000
16,000
18,000
20,000
25,000

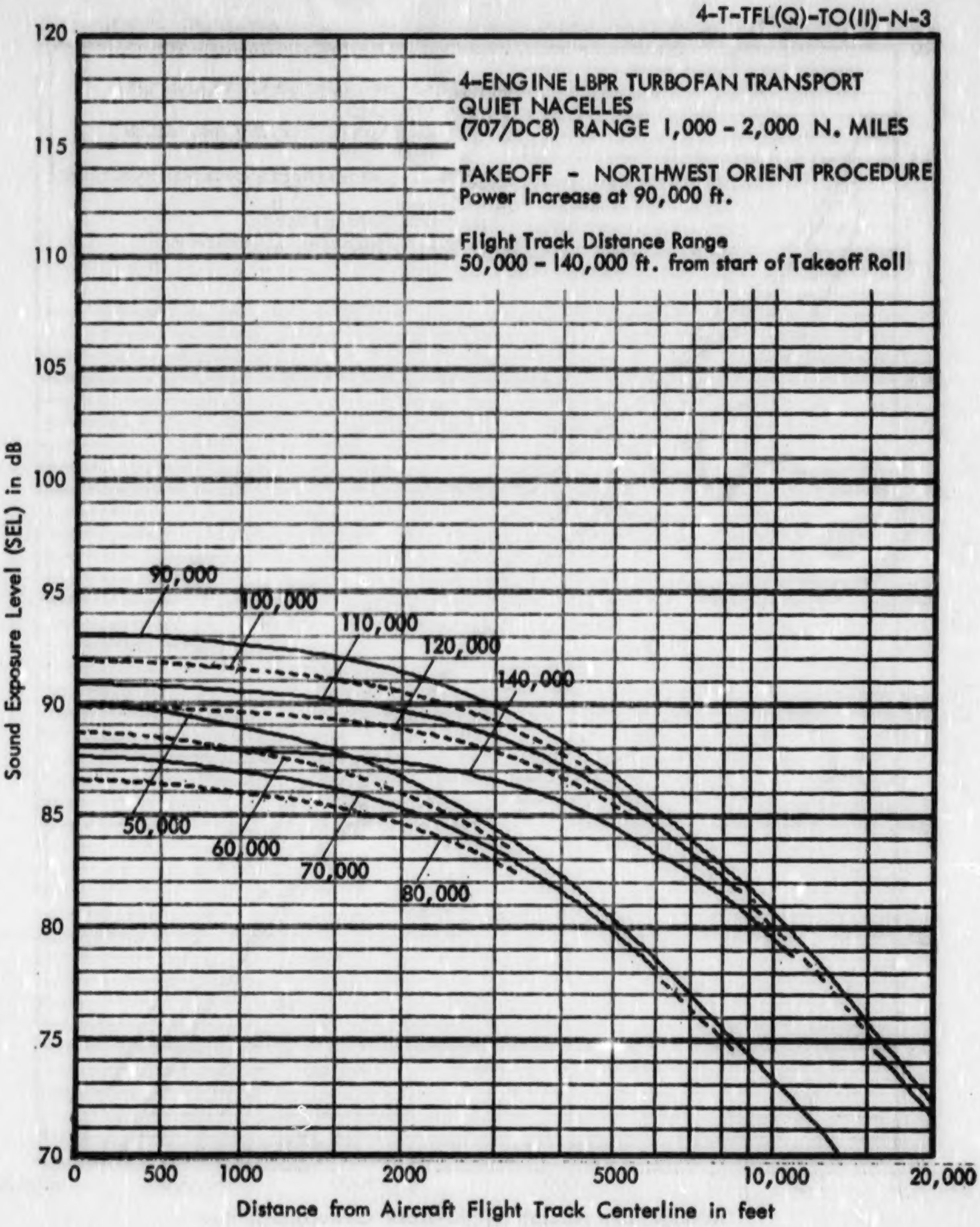
4-T-TFL(Q)-TO(I)-N-3

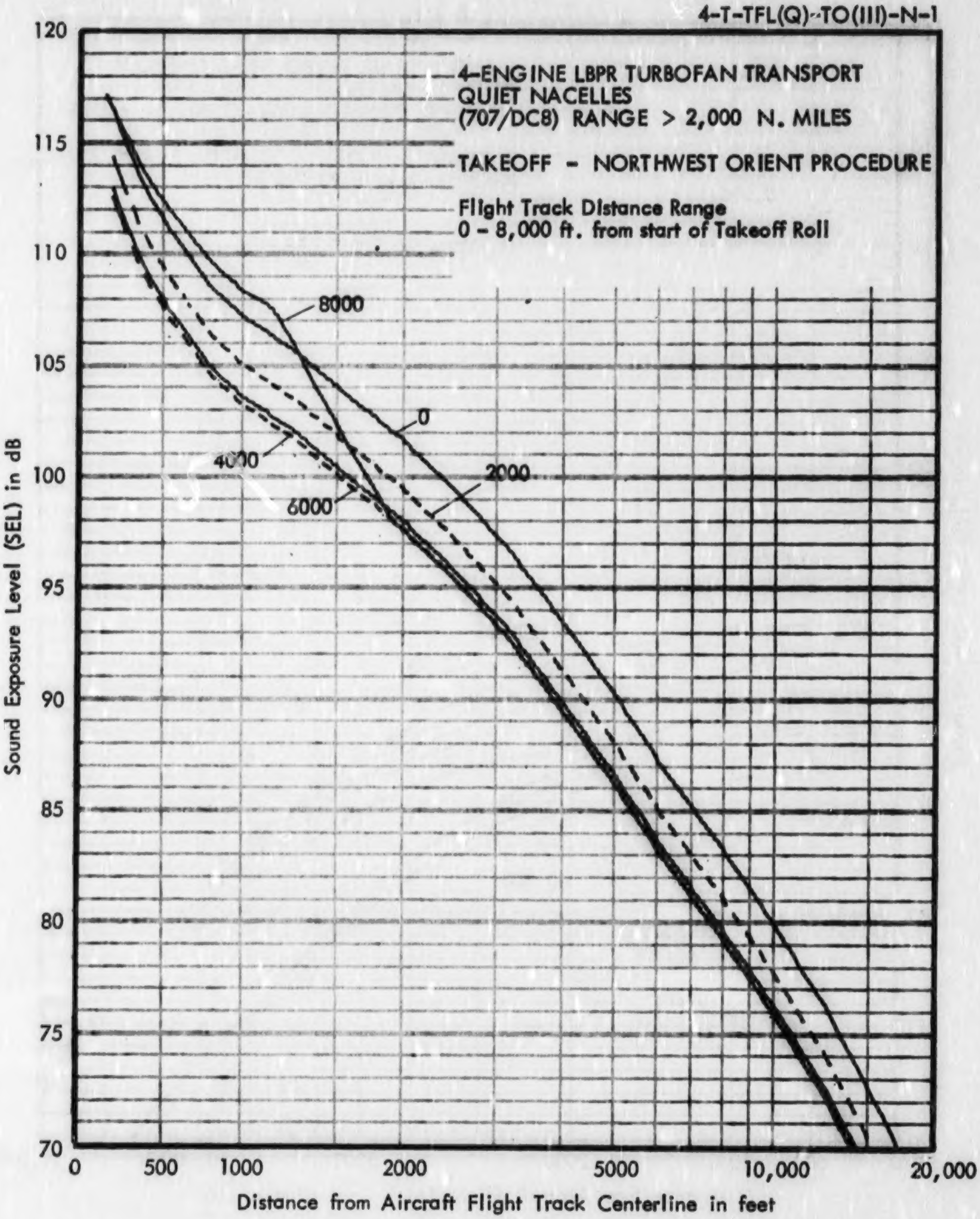



4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
6000
0
4000
2000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

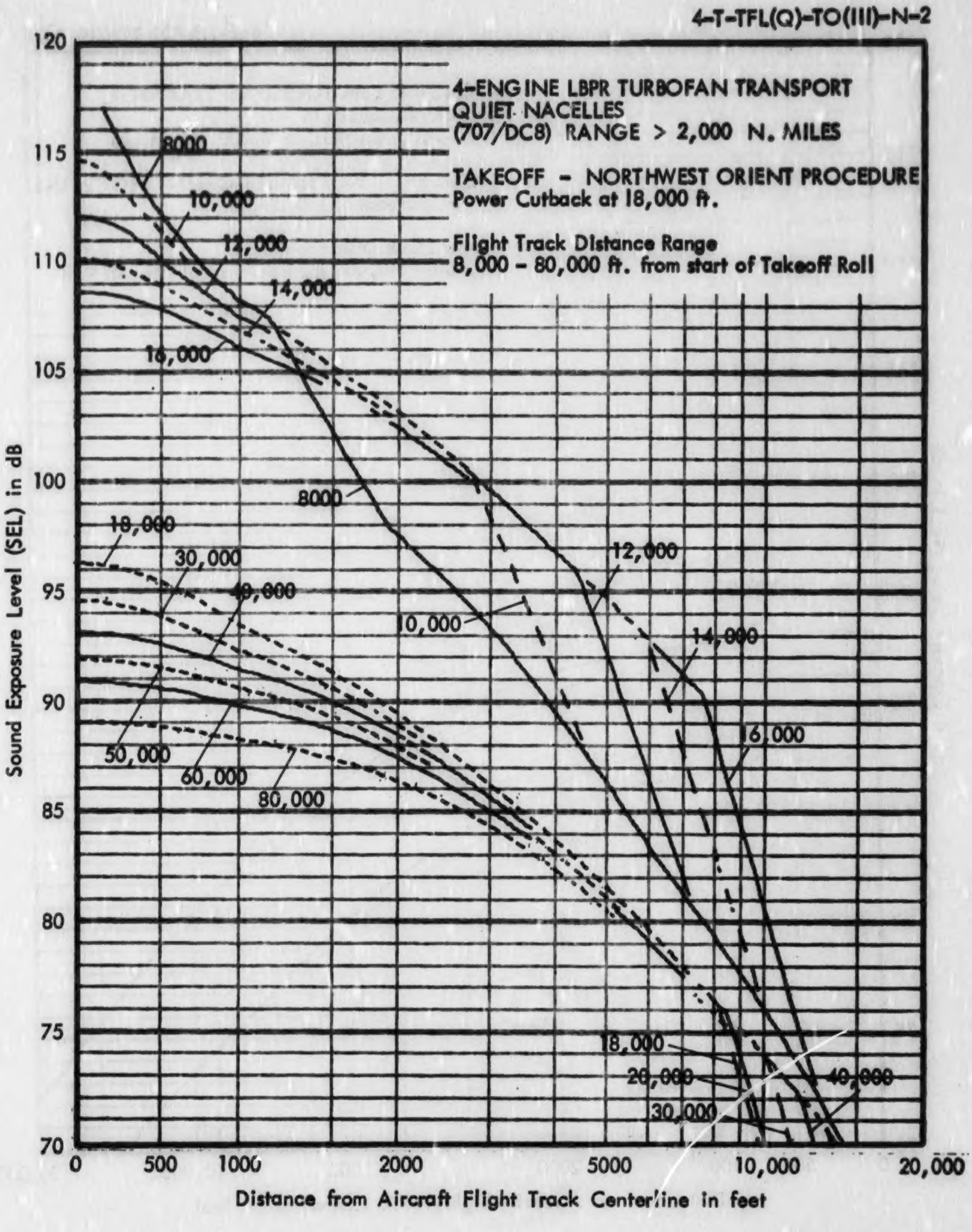

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 14,000 ft.
Flight Track Distance Range
6,000 - 50,000 ft. from start of Takeoff Roll
6000
8000
10,000
8000
10,000
14,000
18,000
30,000
40,000
30,000
14,000
16,000
18,000
20,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

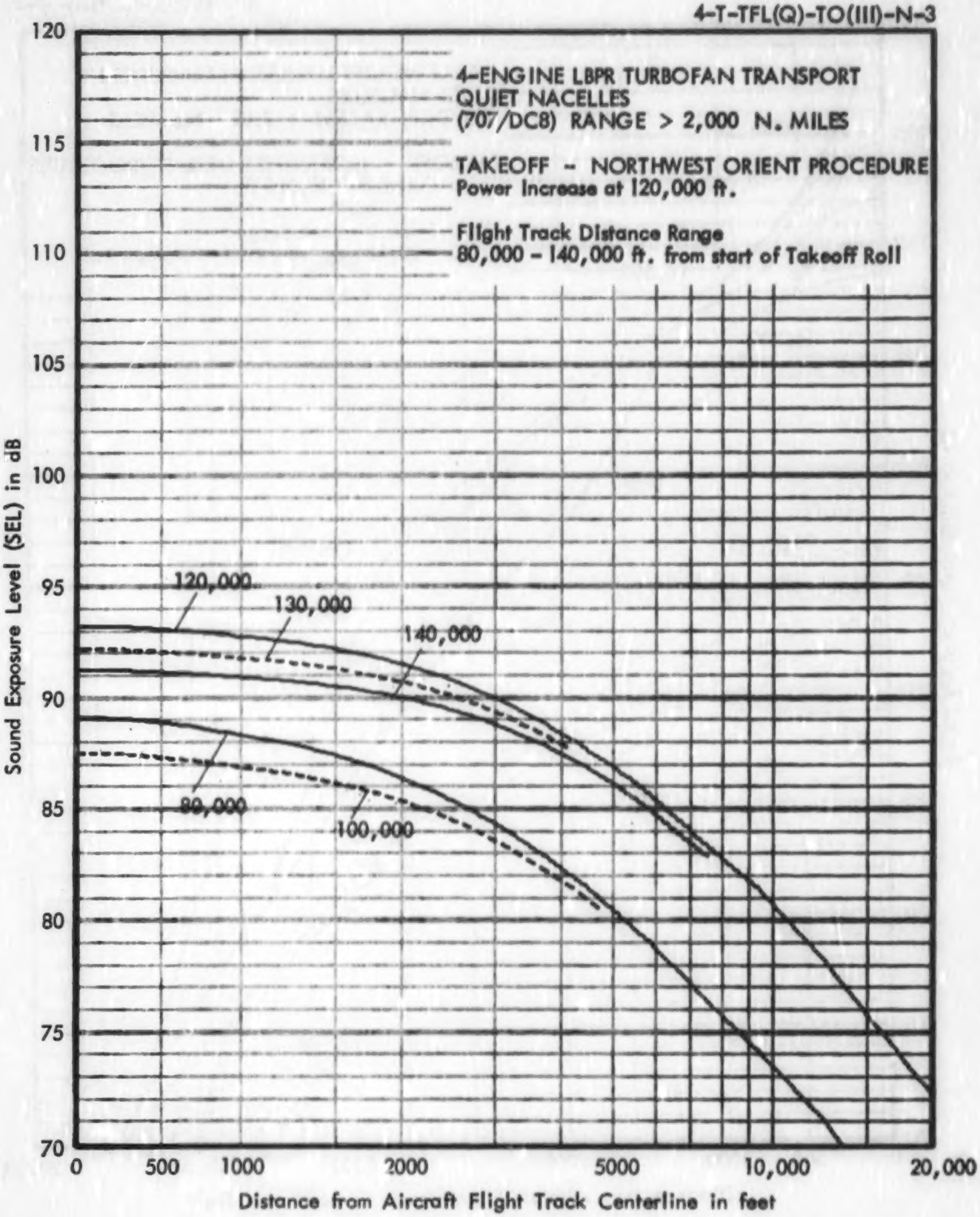
4-T-TFL(Q)-TO(II)-N-3

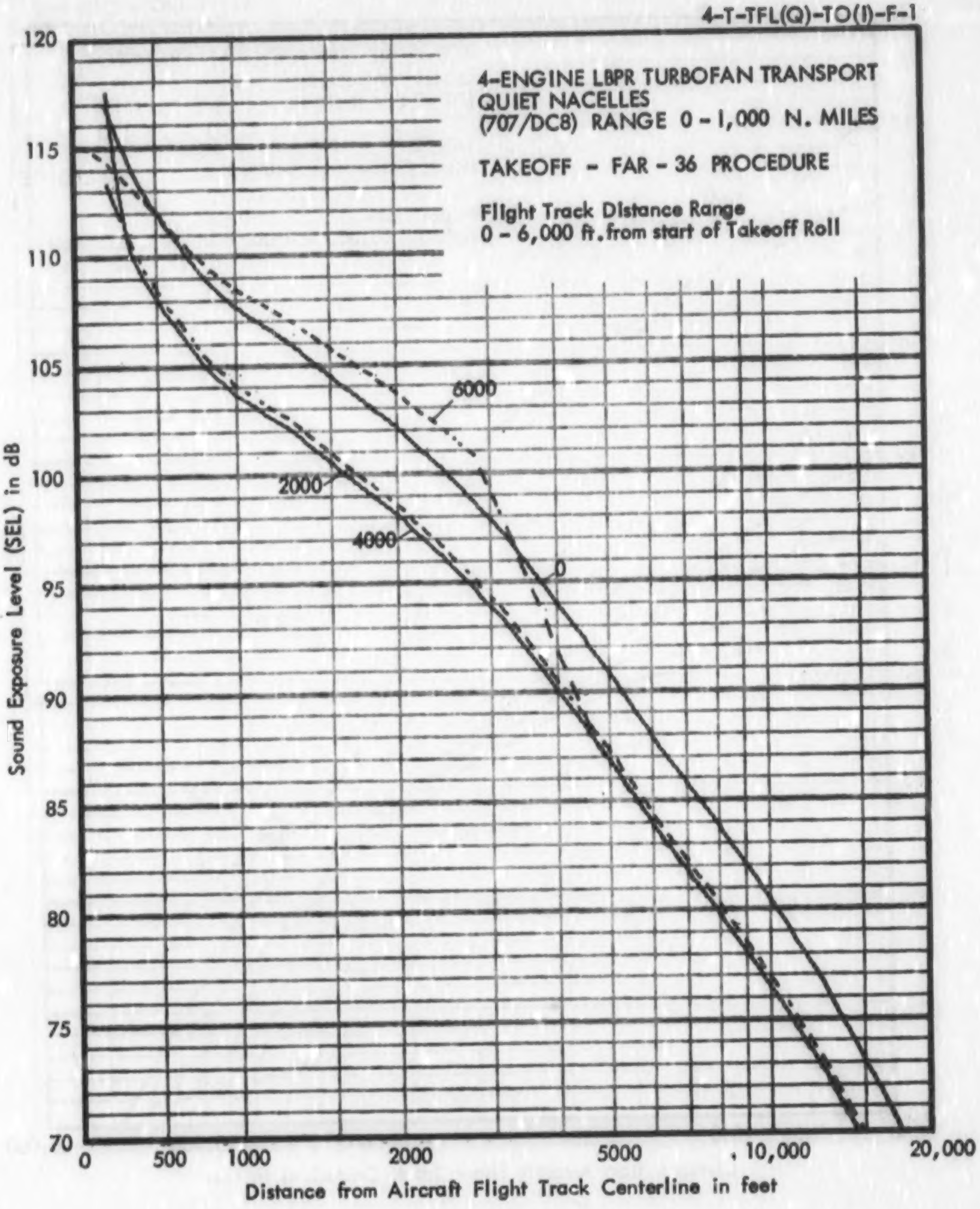



4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE > 2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0 - 8,000 ft. from start of Takeoff Roll
8000
0
4000
2000
6000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

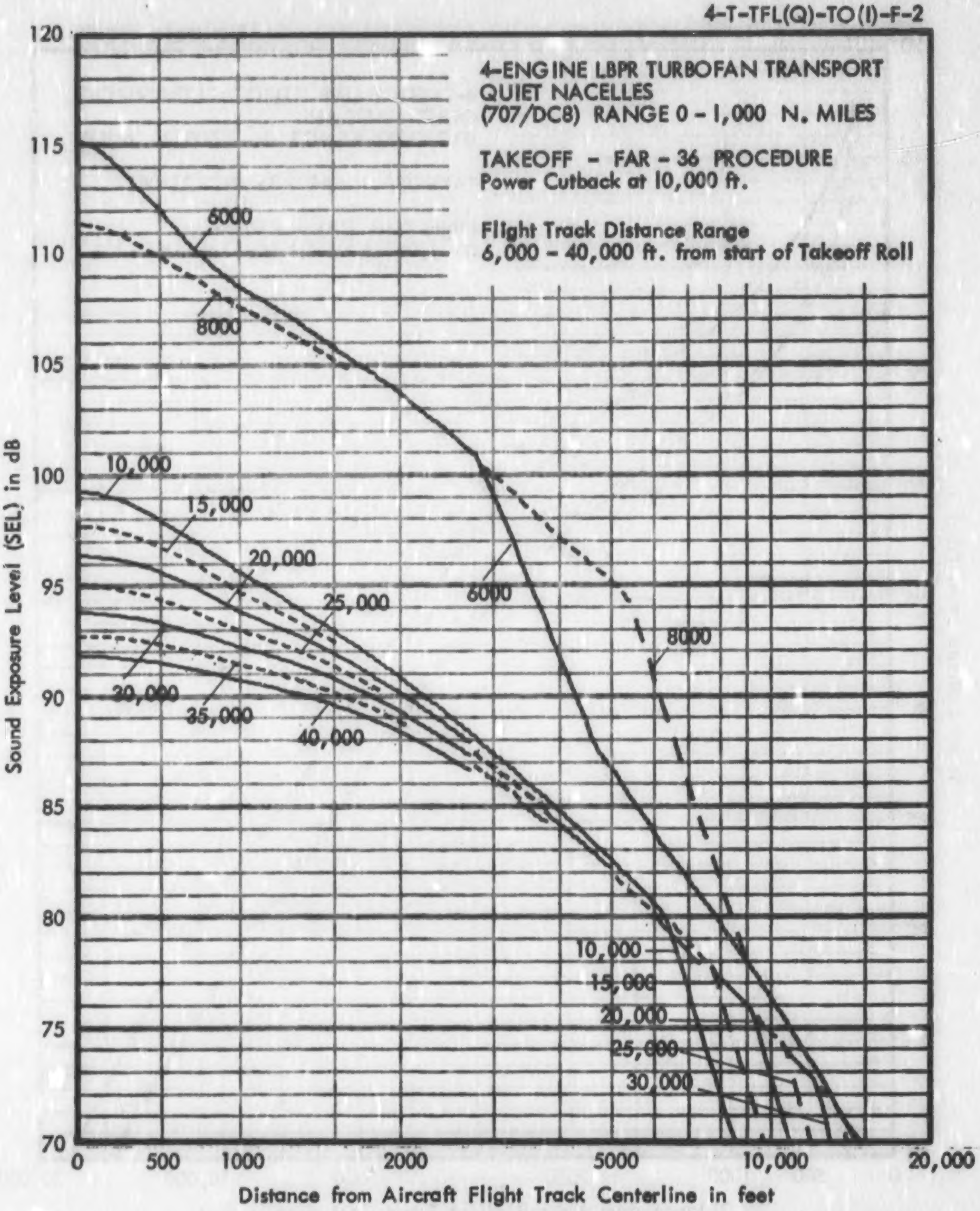
4-T-TFL(Q)-TO(III)-N-2

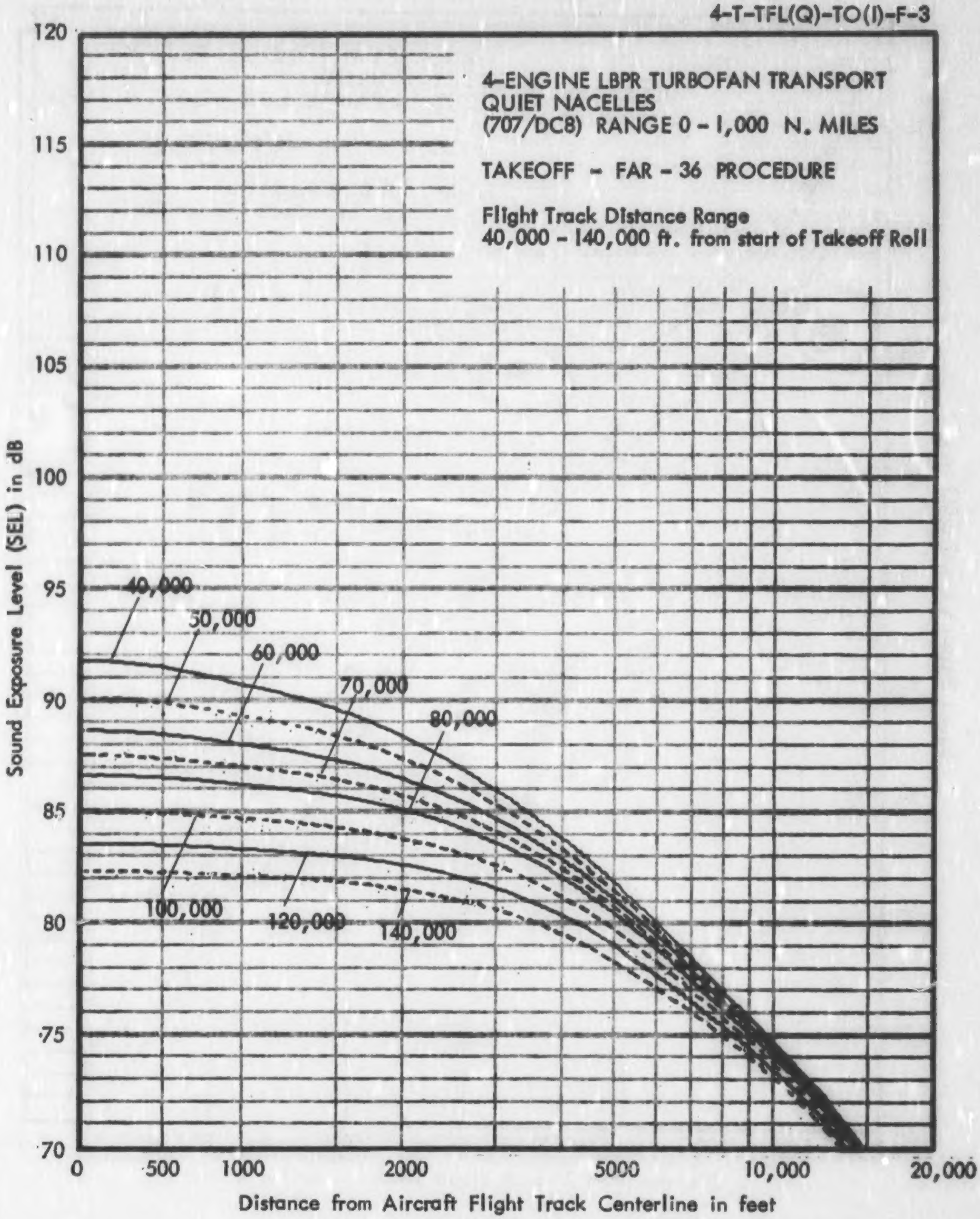



4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE > 2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 120,000 ft.
Flight Track Distance Range
80,000 - 140,000 ft. from start of Takeoff Roll
120,000
130,000
140,000
80,000
100,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

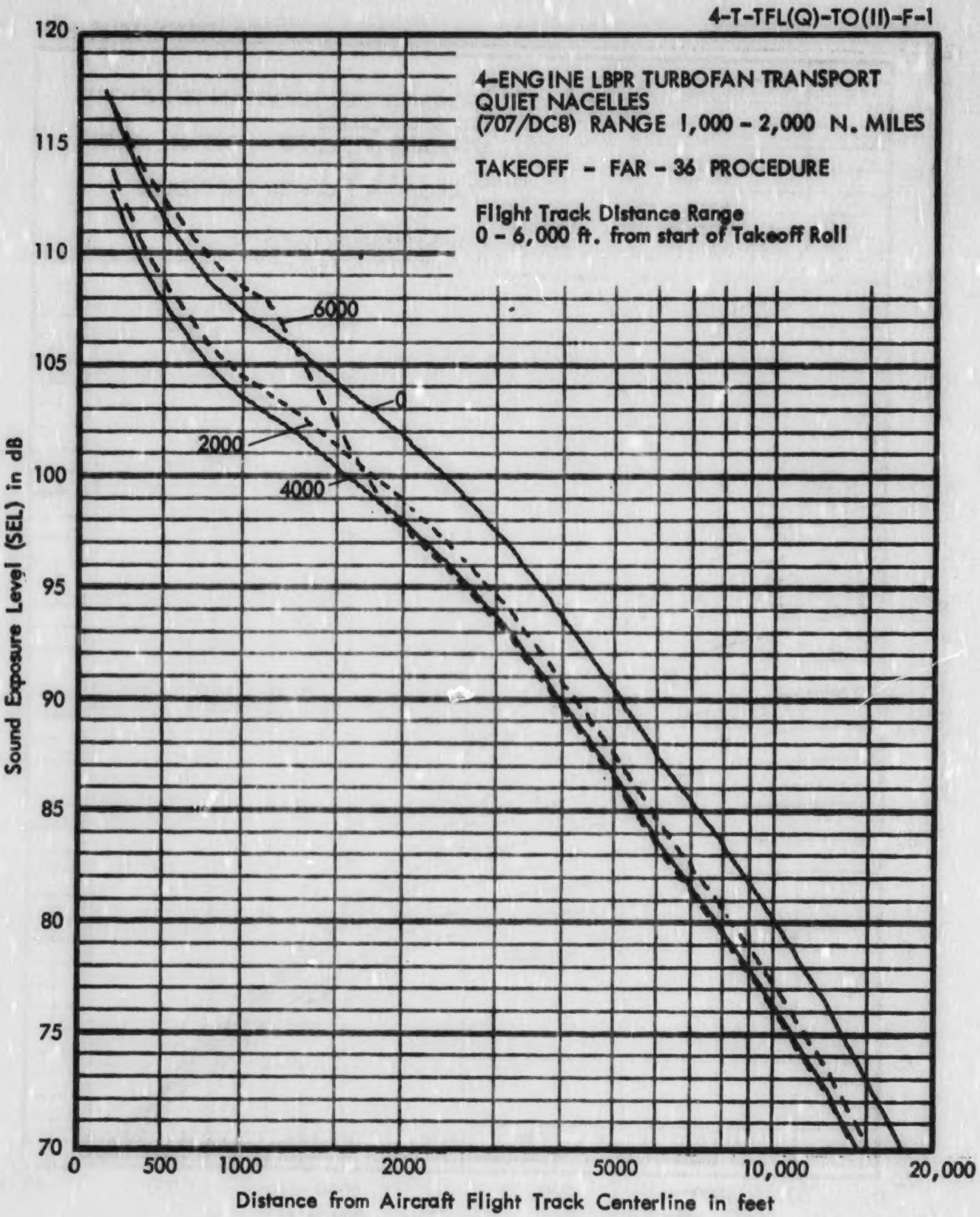

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range
0 - 6,000 ft. from start of Takeoff Roll
6000
2000
4000
0
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

4-T-TFL(Q)-TO(I)-F-2

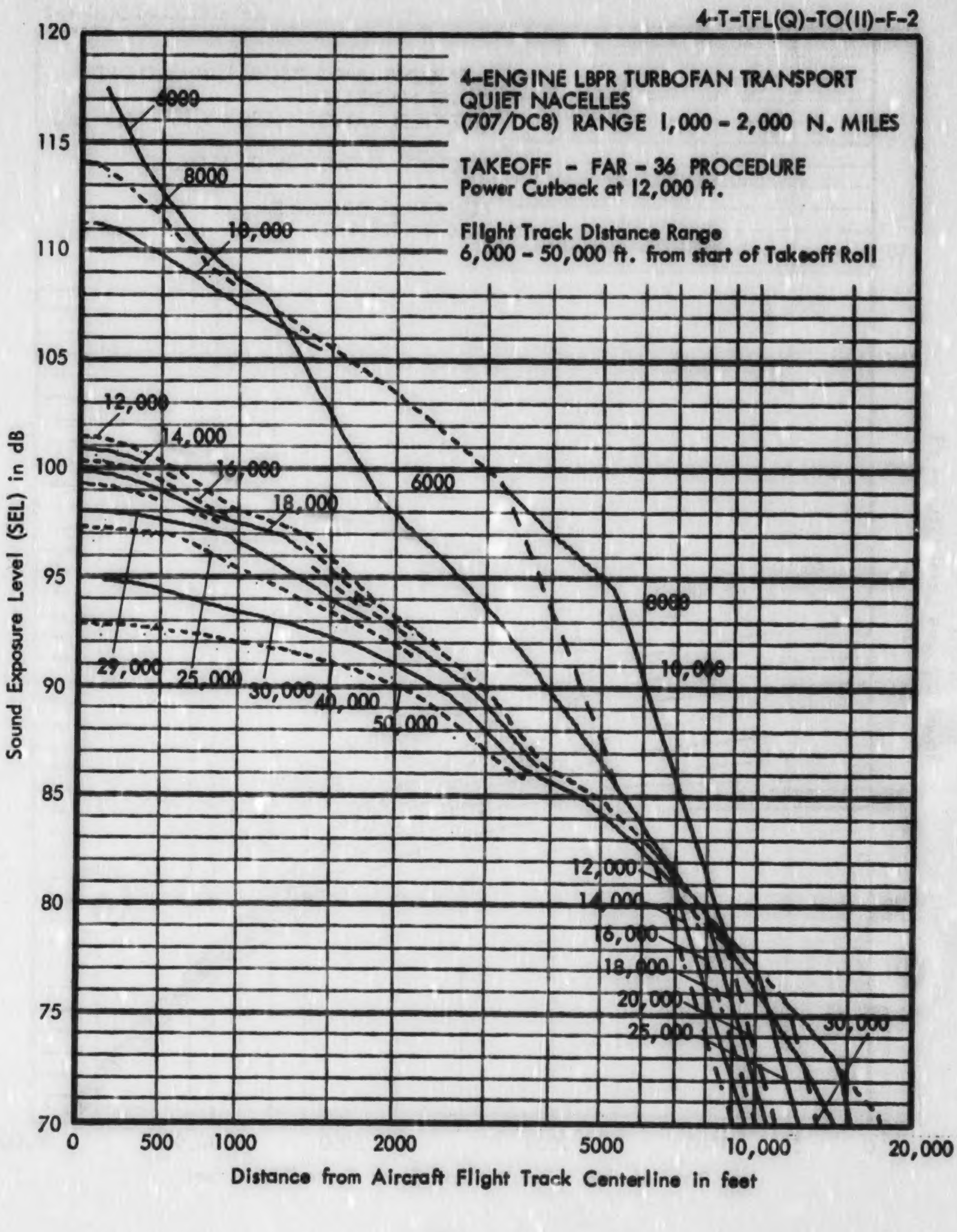


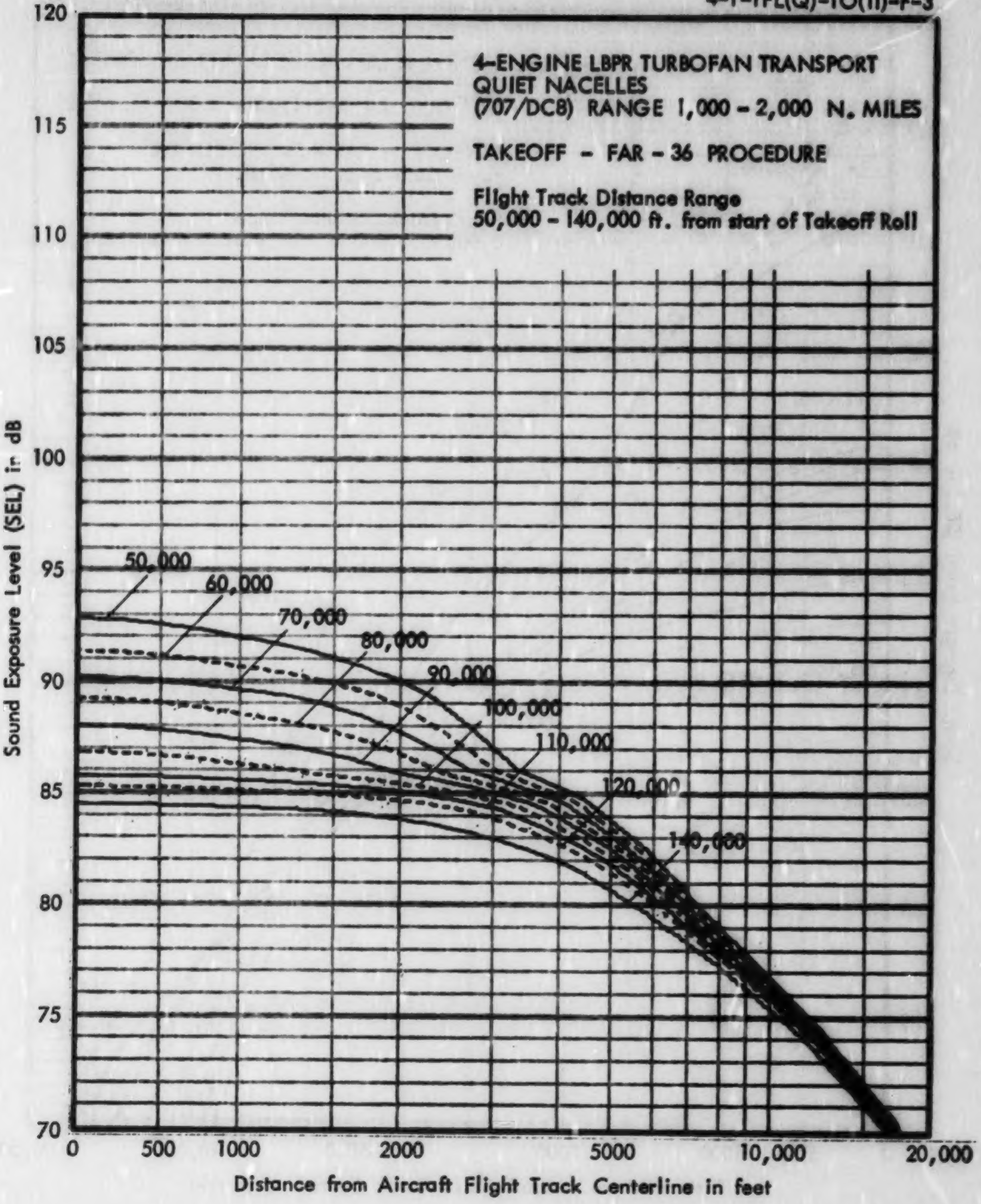

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 0 - 1,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range
40,000 - 140,000 ft. from start of Takeoff Roll
40,000
50,000
60,000
70,000
80,000
100,000
120,000
140,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

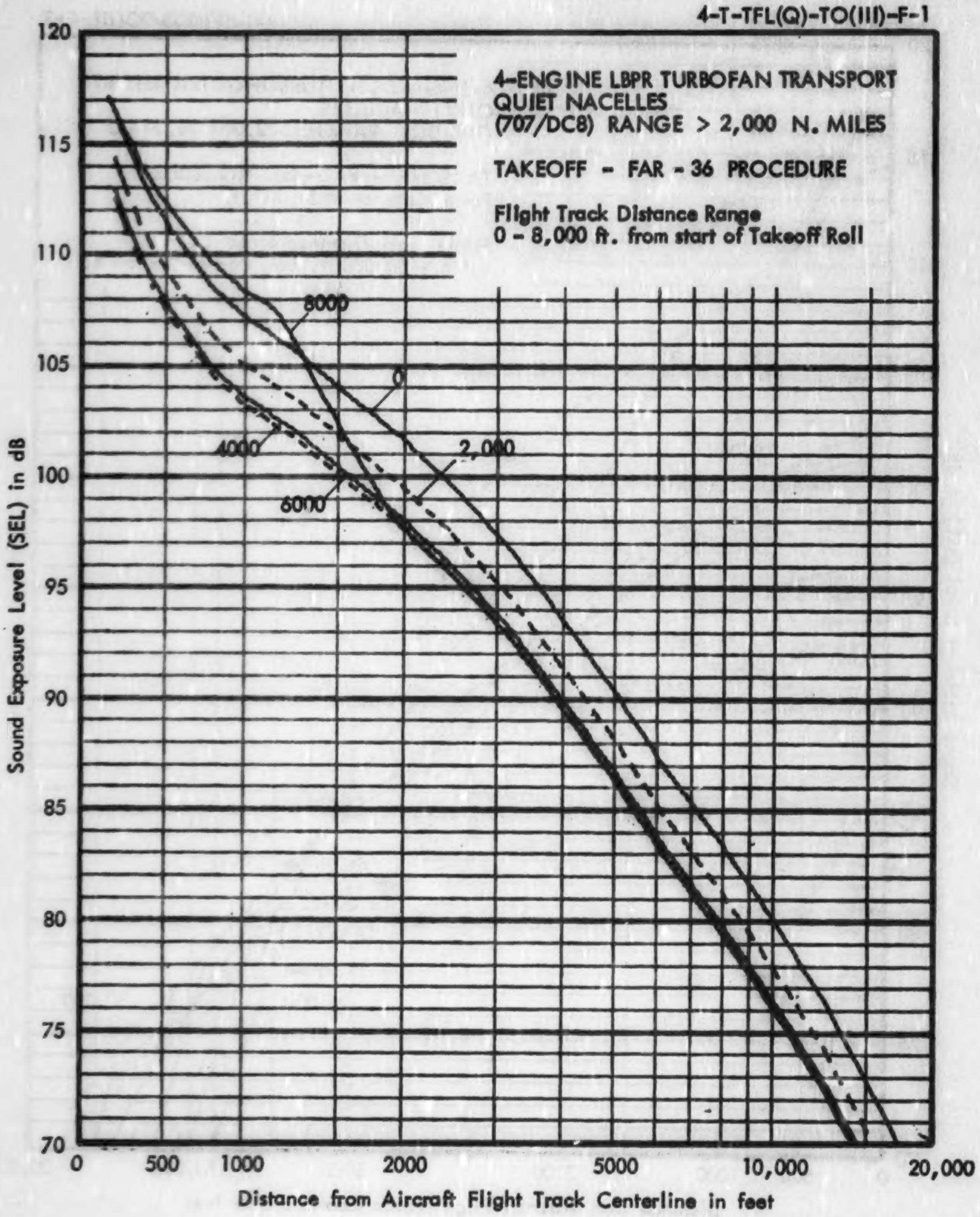
4-T-TFL(Q)-TO(II)-F-1



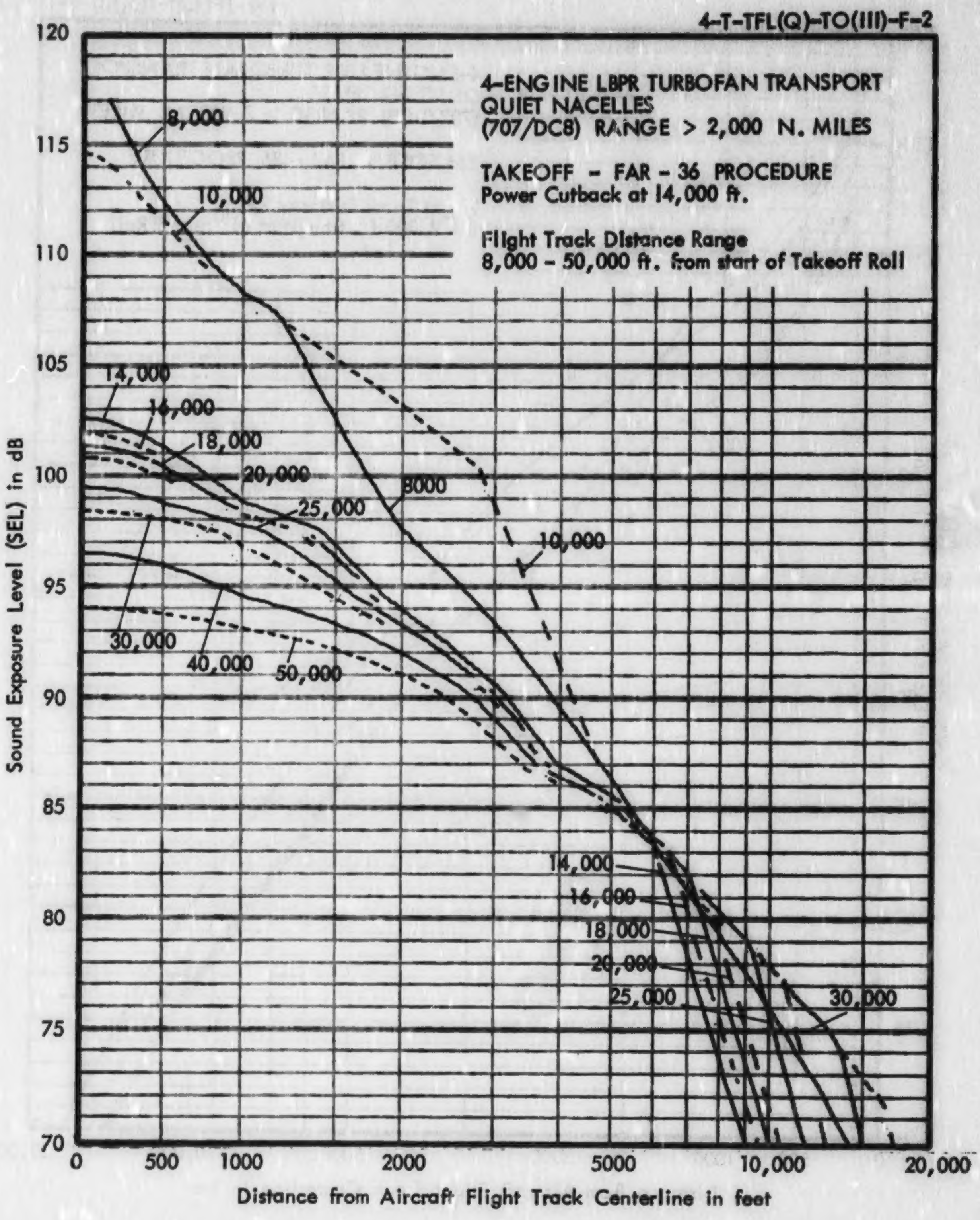
4-T-TFL(Q)-TO(II)-F-2



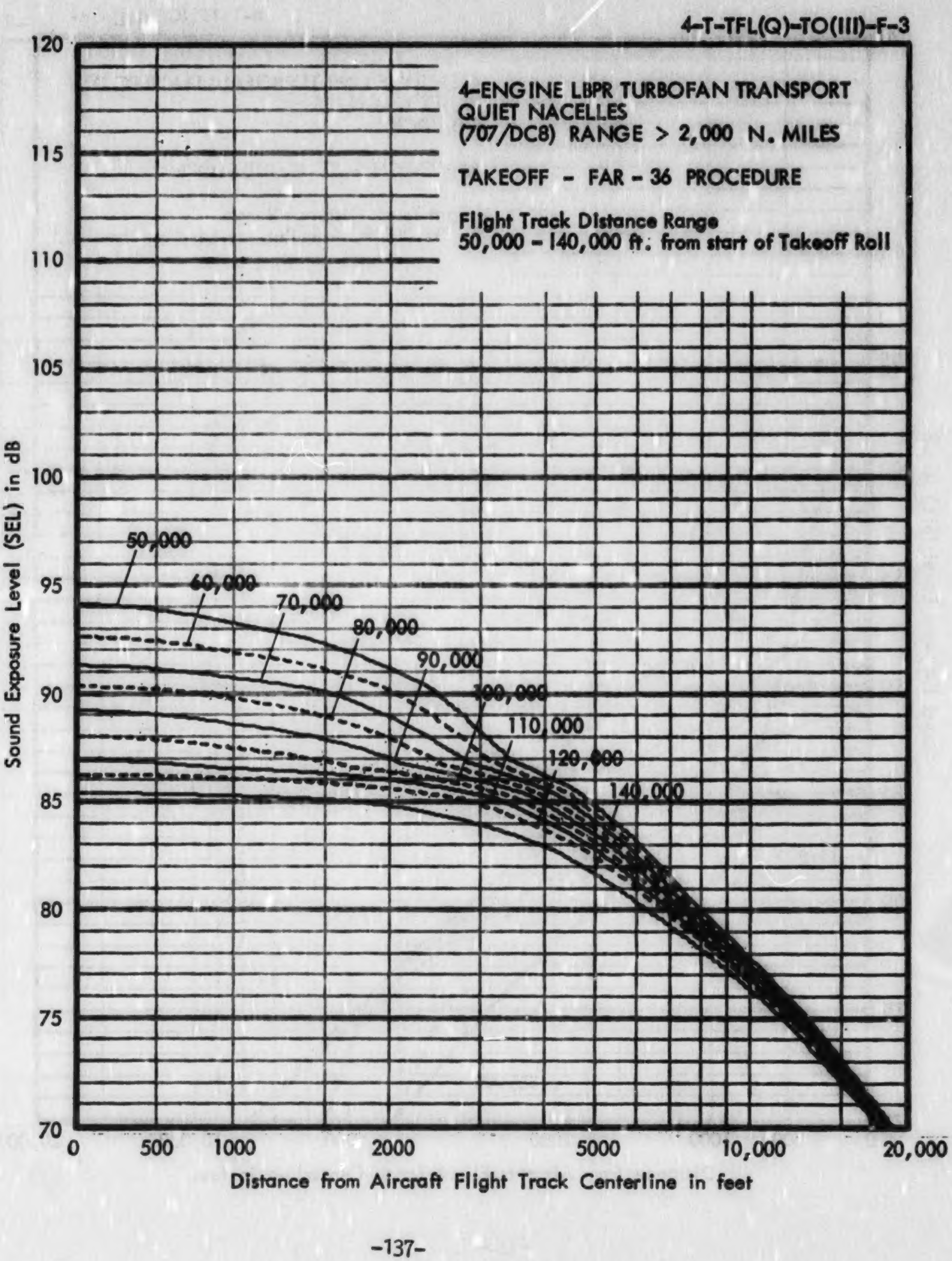

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE 1,000 - 2,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range
50,000 - 140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8) RANGE > 2,000 N. MILES
TAKEOFF - FAR - 36 PROCEDURE
Flight Track Distance Range
0 - 8,000 ft. from start of Takeoff Roll
8000
0
4000
2,000
6000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

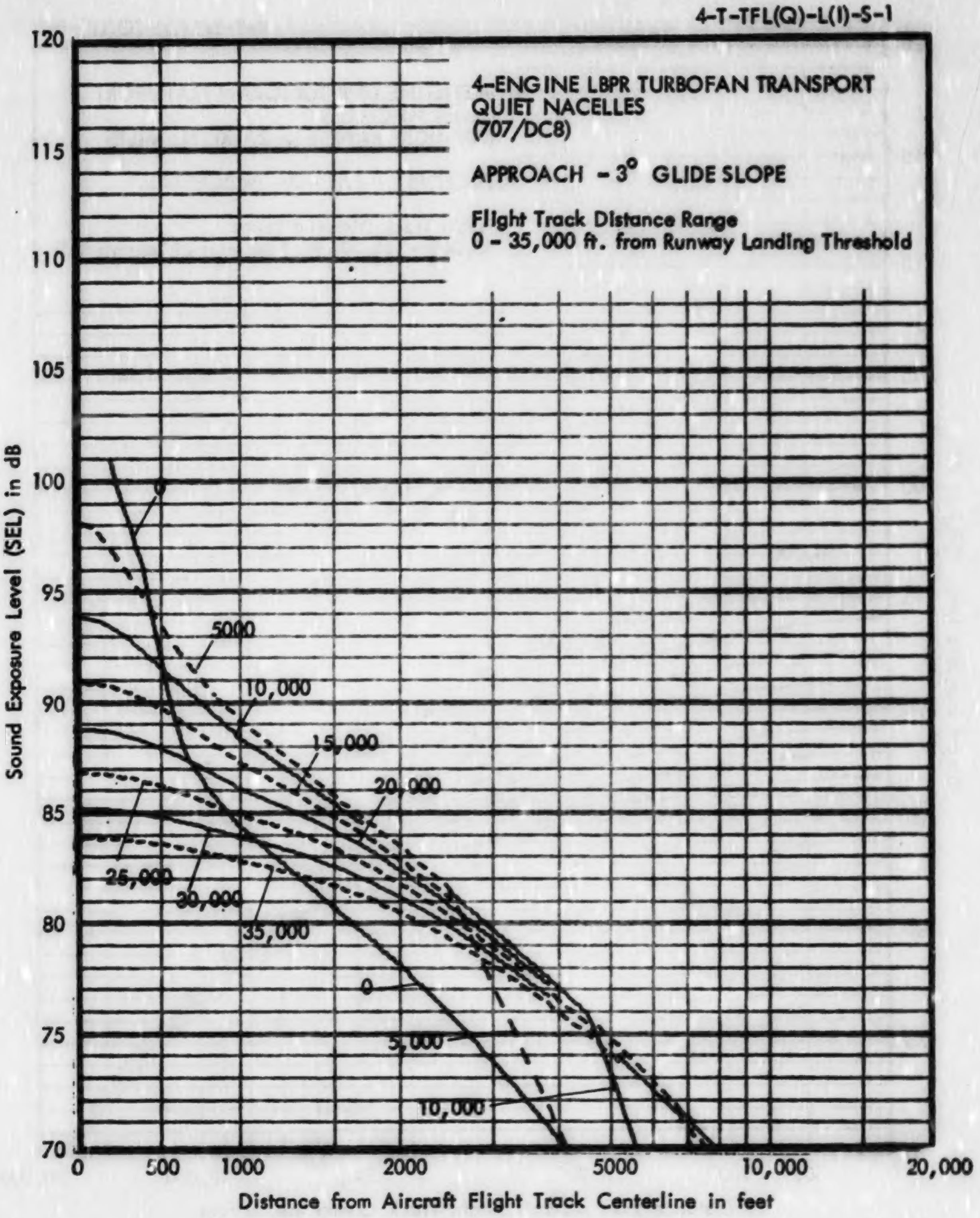
4-T-TFL(Q)-TO(III)-F-2

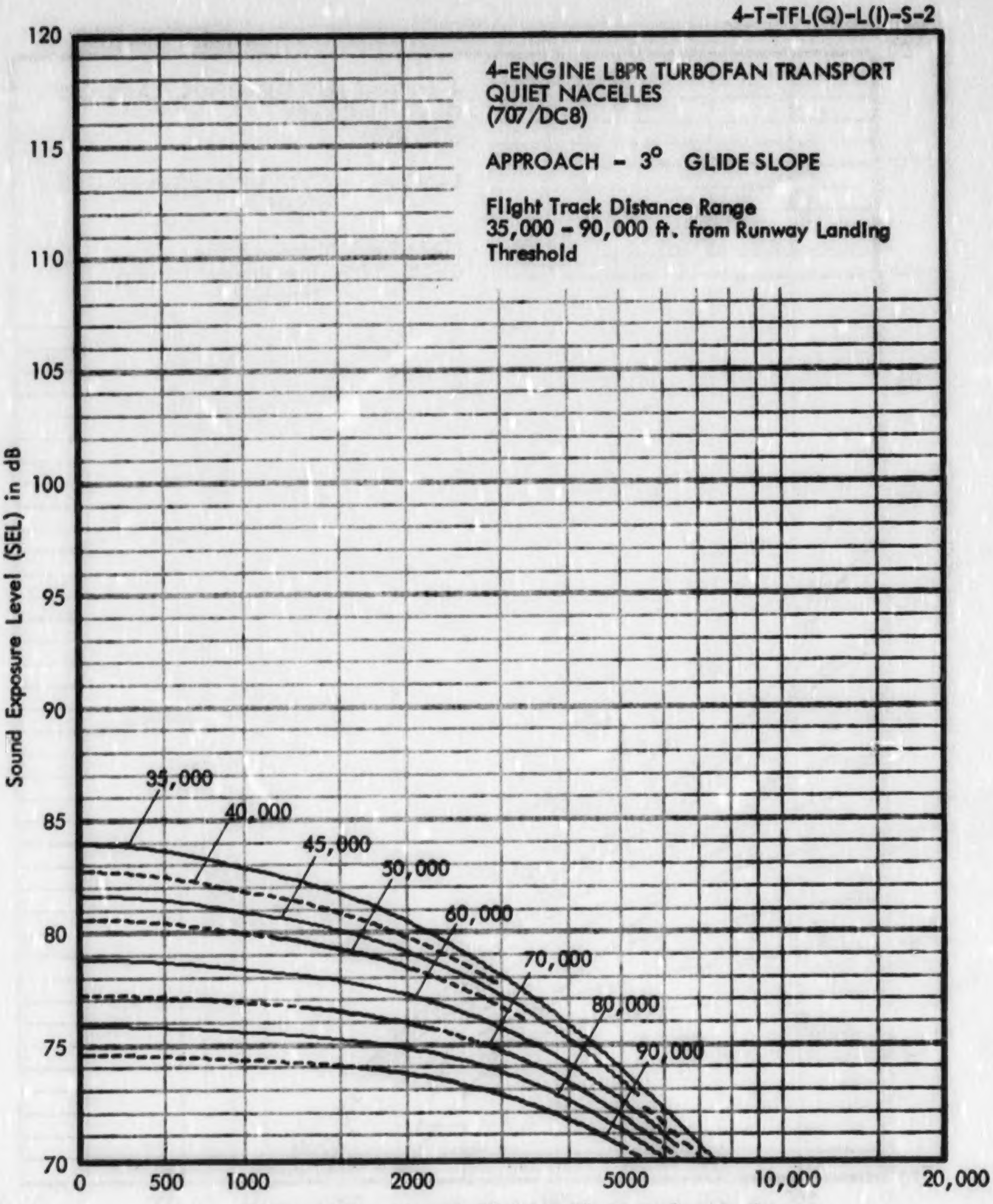


4-T-TFL(Q)-TO(III)-F-3

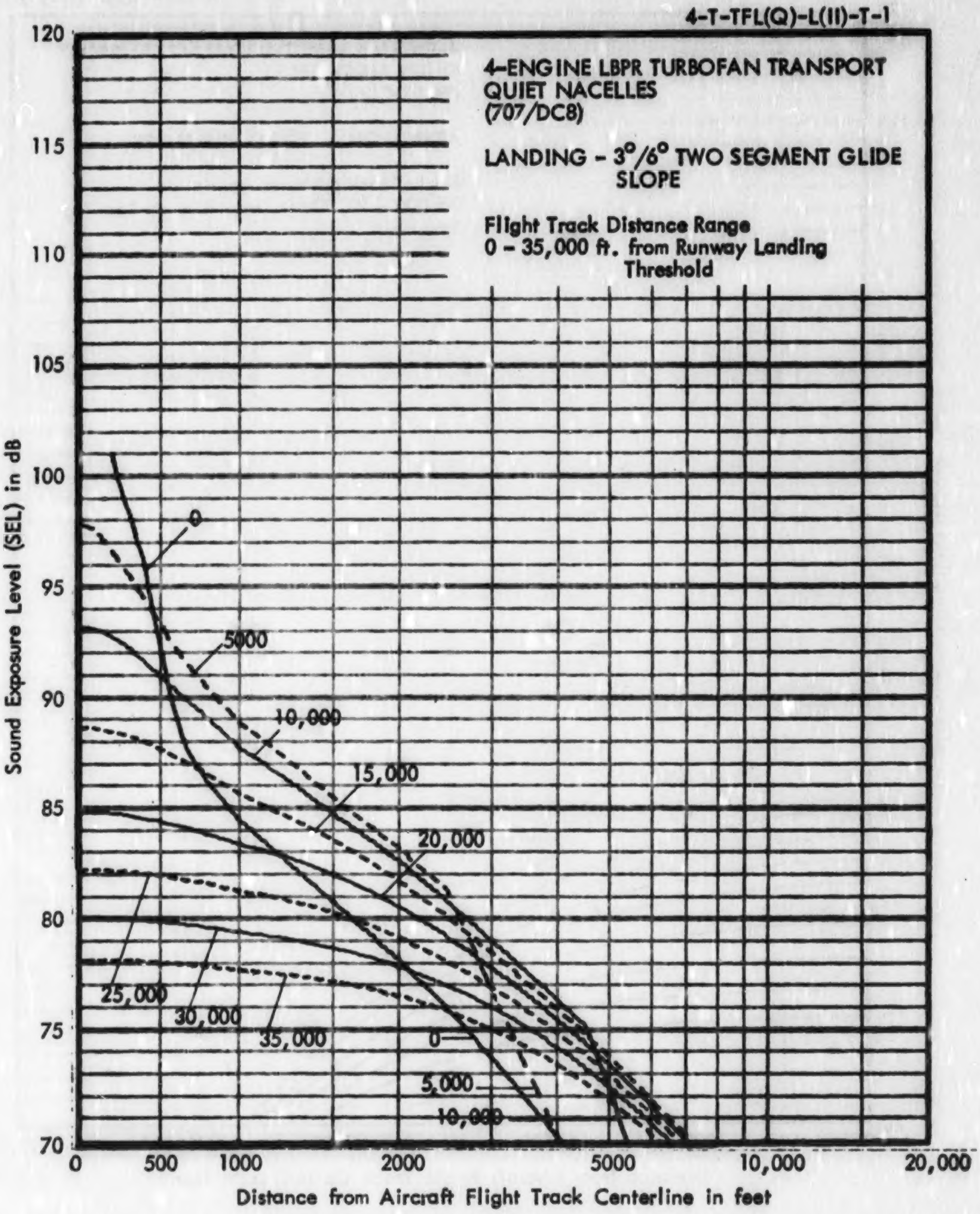


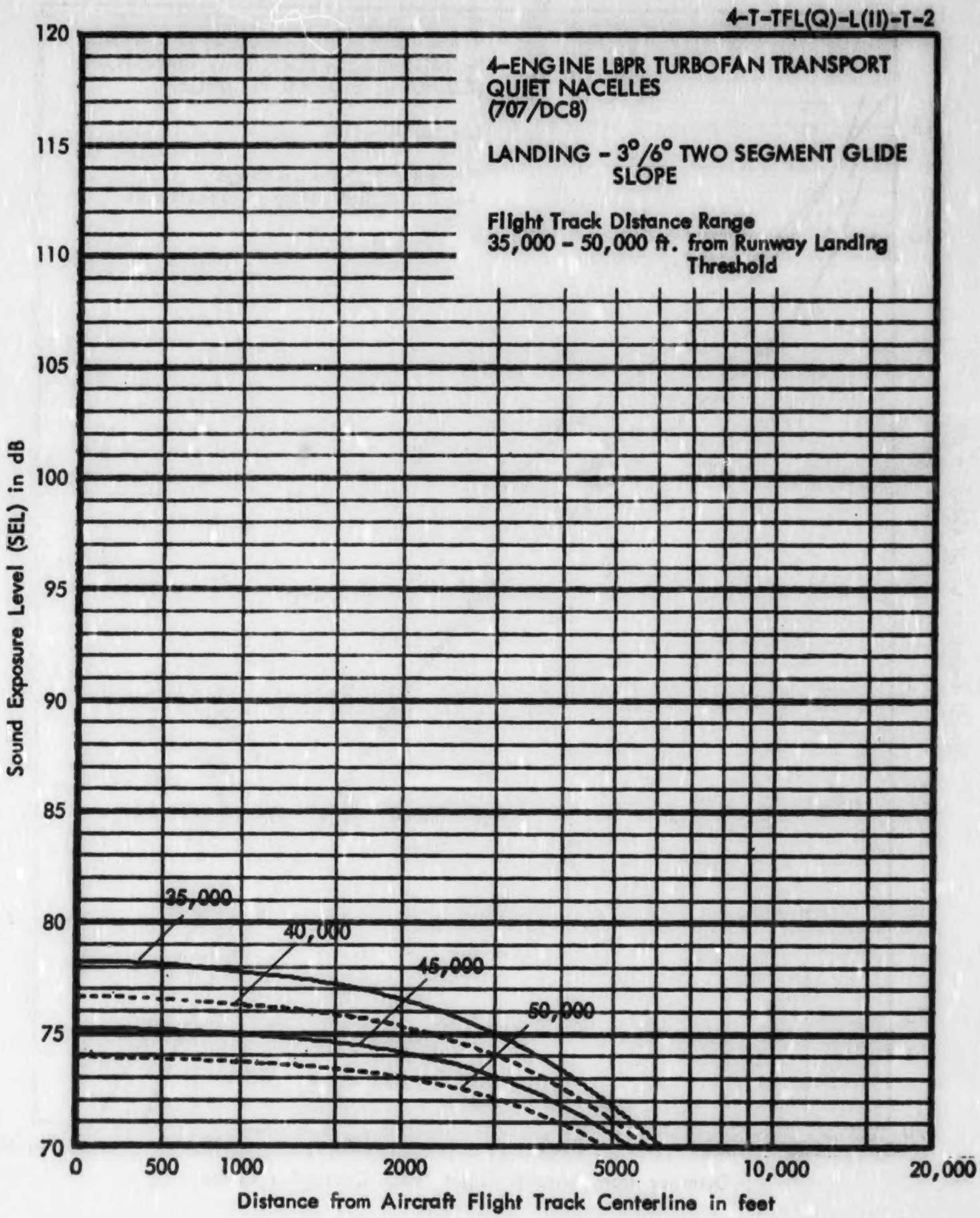
4-T-TFL(Q)-L(I)-S-1

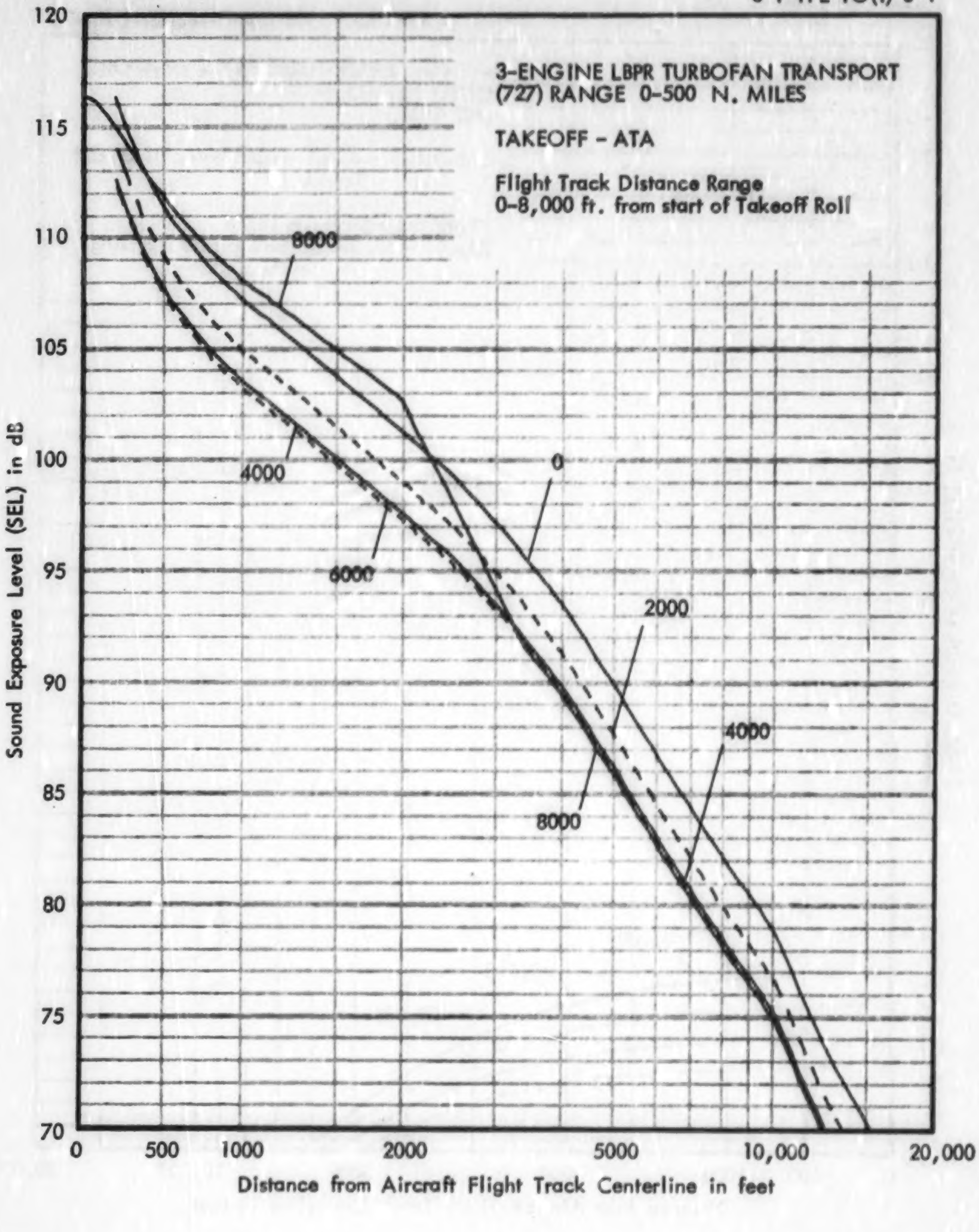

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8)
APPROACH – 3° GLIDE SLOPE
Flight Track Distance Range
0 – 35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5,000
10,000

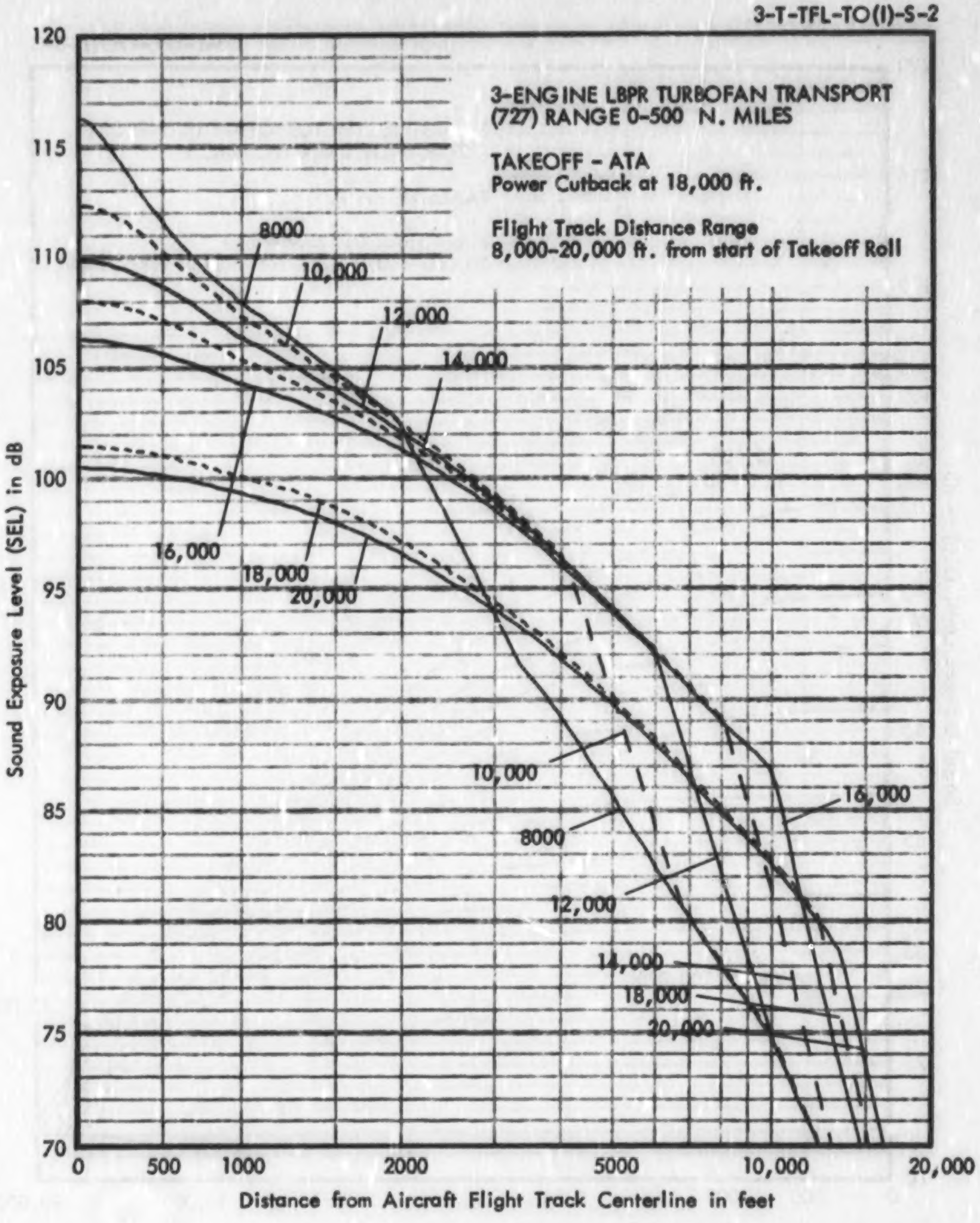

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8)
APPROACH - 3° GLIDE SLOPE
Flight Track Distance Range
35,000 - 90,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
50,000
60,000
70,000
80,000
90,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

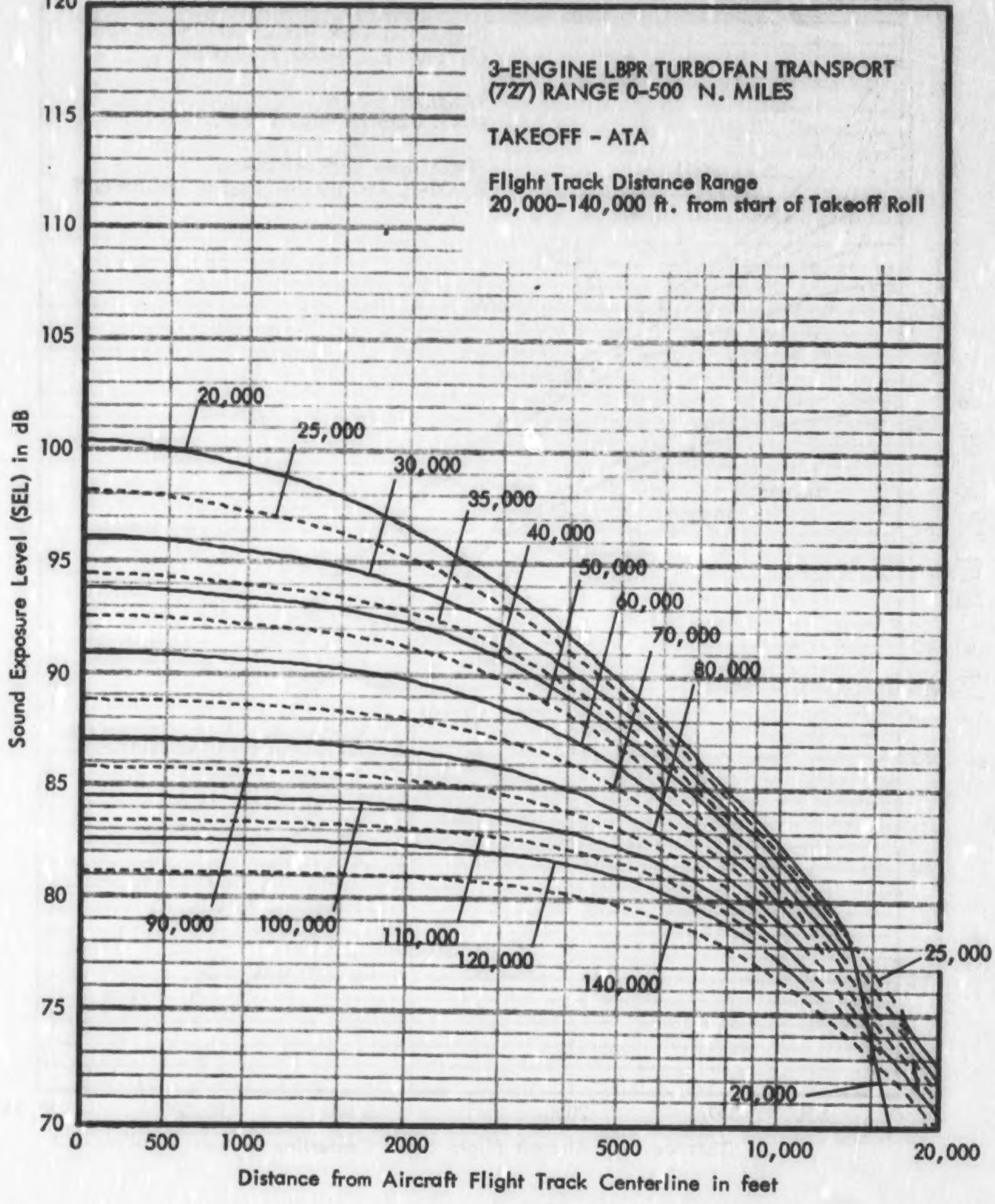
4-T-TFL(Q)-L(II)-T-1

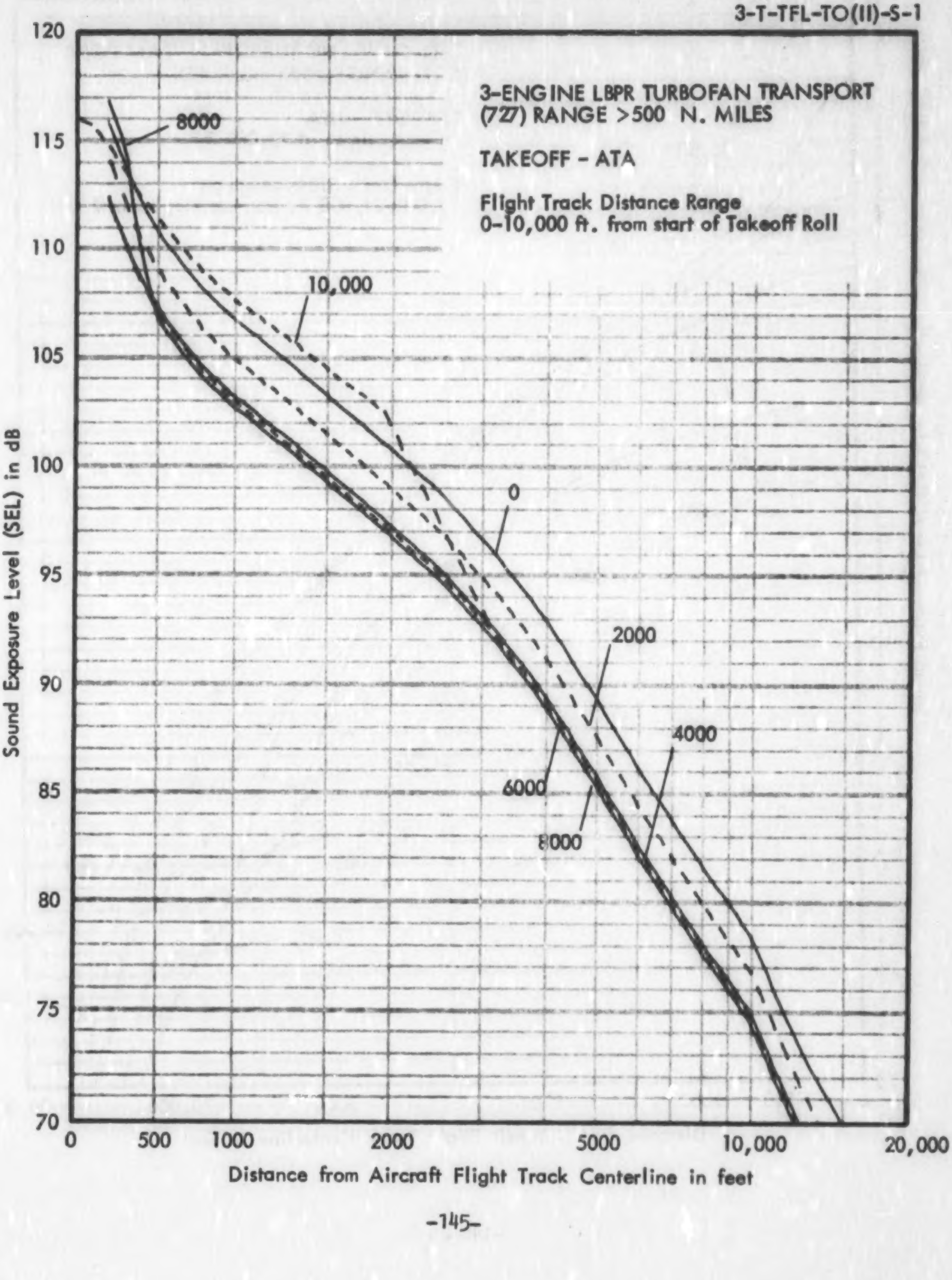


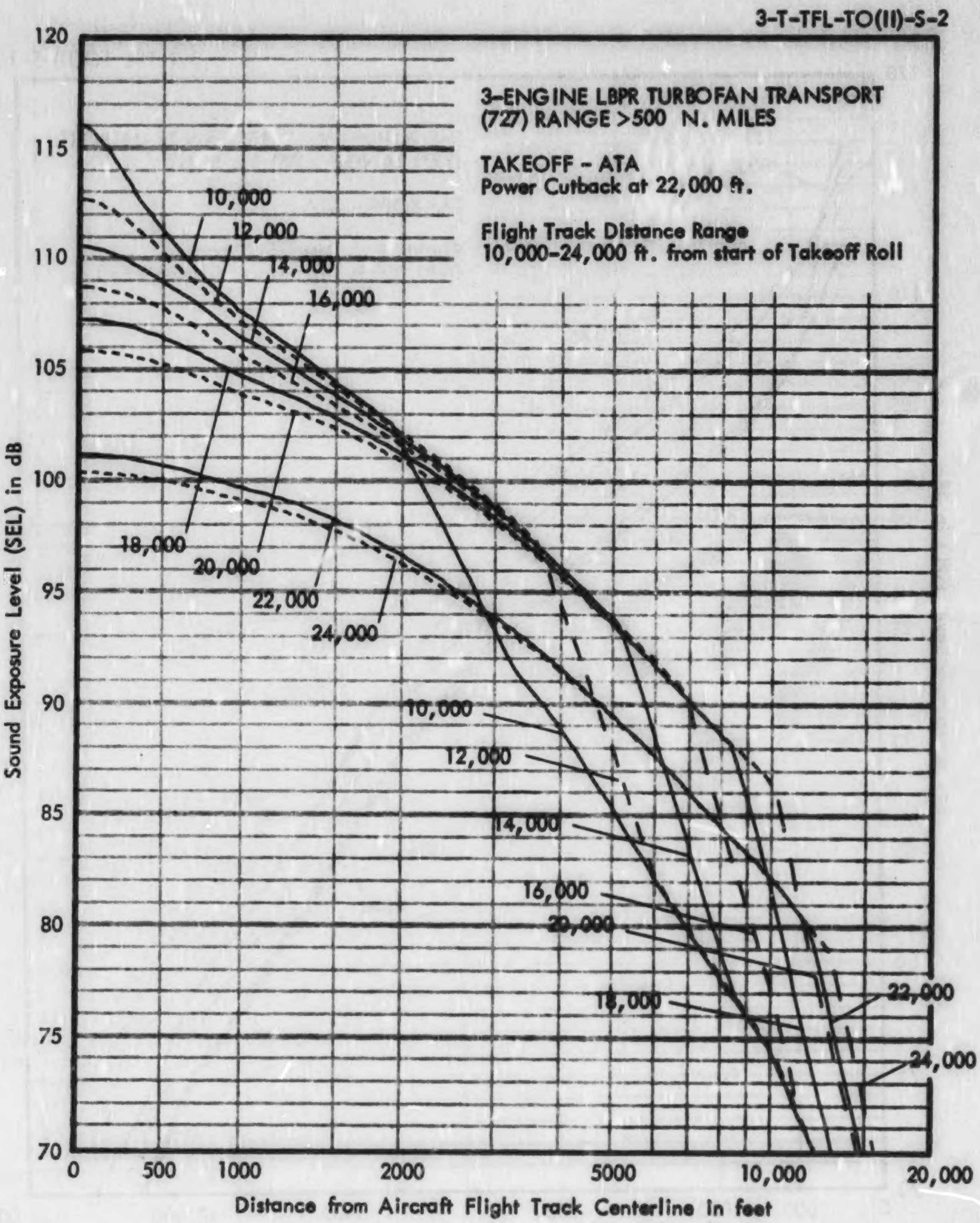

4-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(707/DC8)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range
35,000 - 50,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
50,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
8000
4000
6000
0
2000
4000
8000

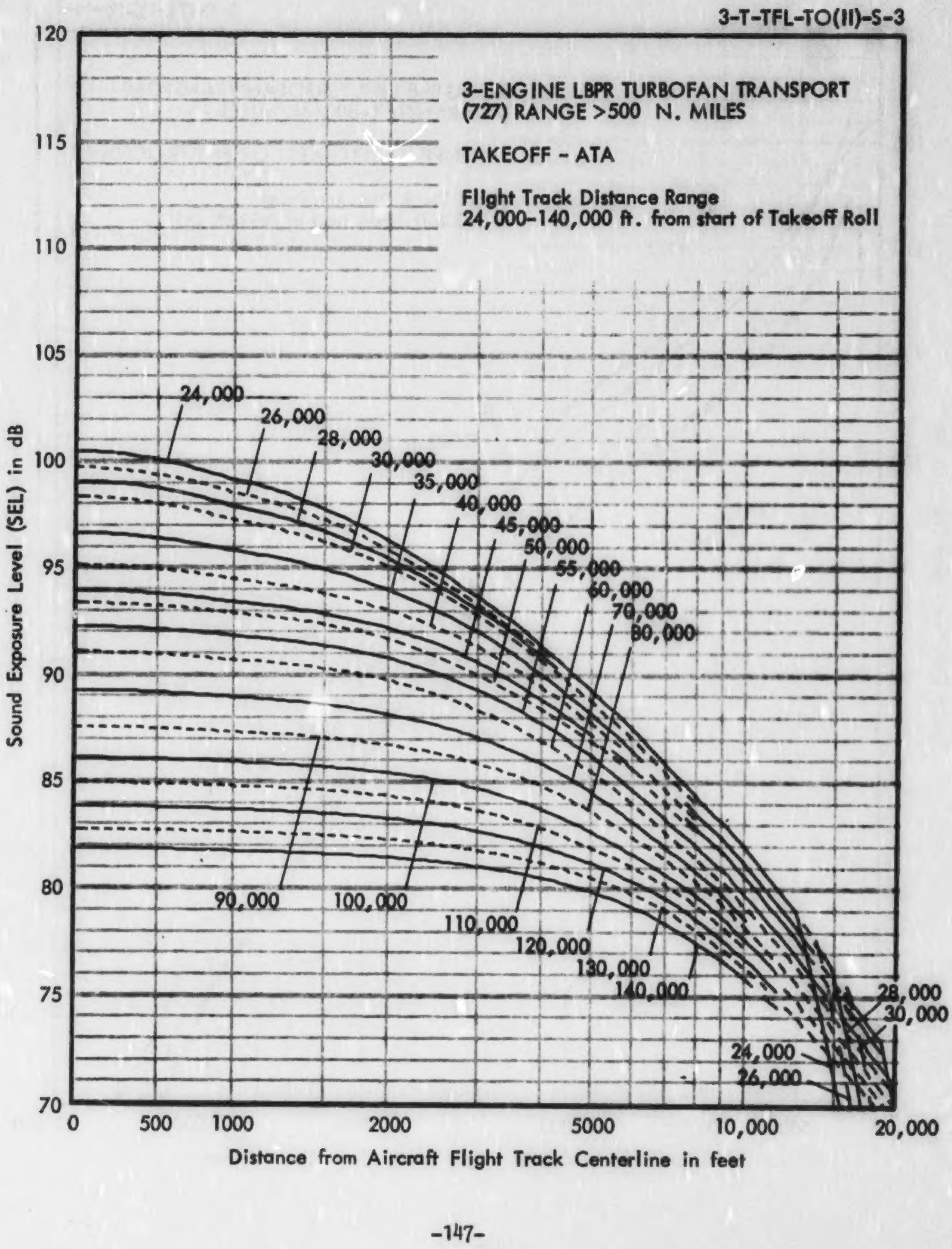

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - ATA
Power Cutback at 18,000 ft.
Flight Track Distance Range
8,000-20,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
10,000
8000
12,000
16,000
14,000
18,000
20,000


3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
20,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
20,000
25,000
30,000
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
140,000
25,000
20,000

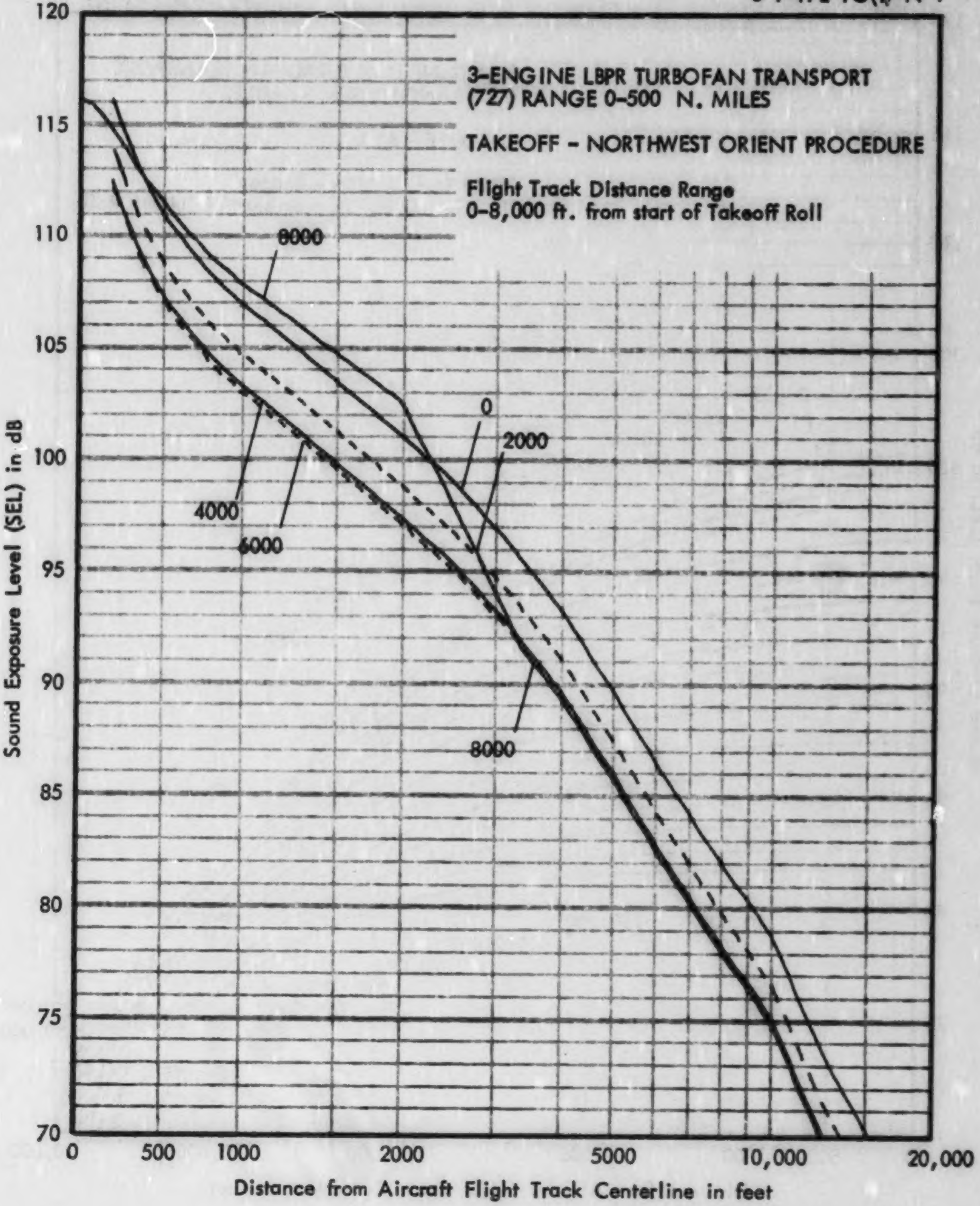

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE >500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
8000
10,000
0
2000
4000
6000
8000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

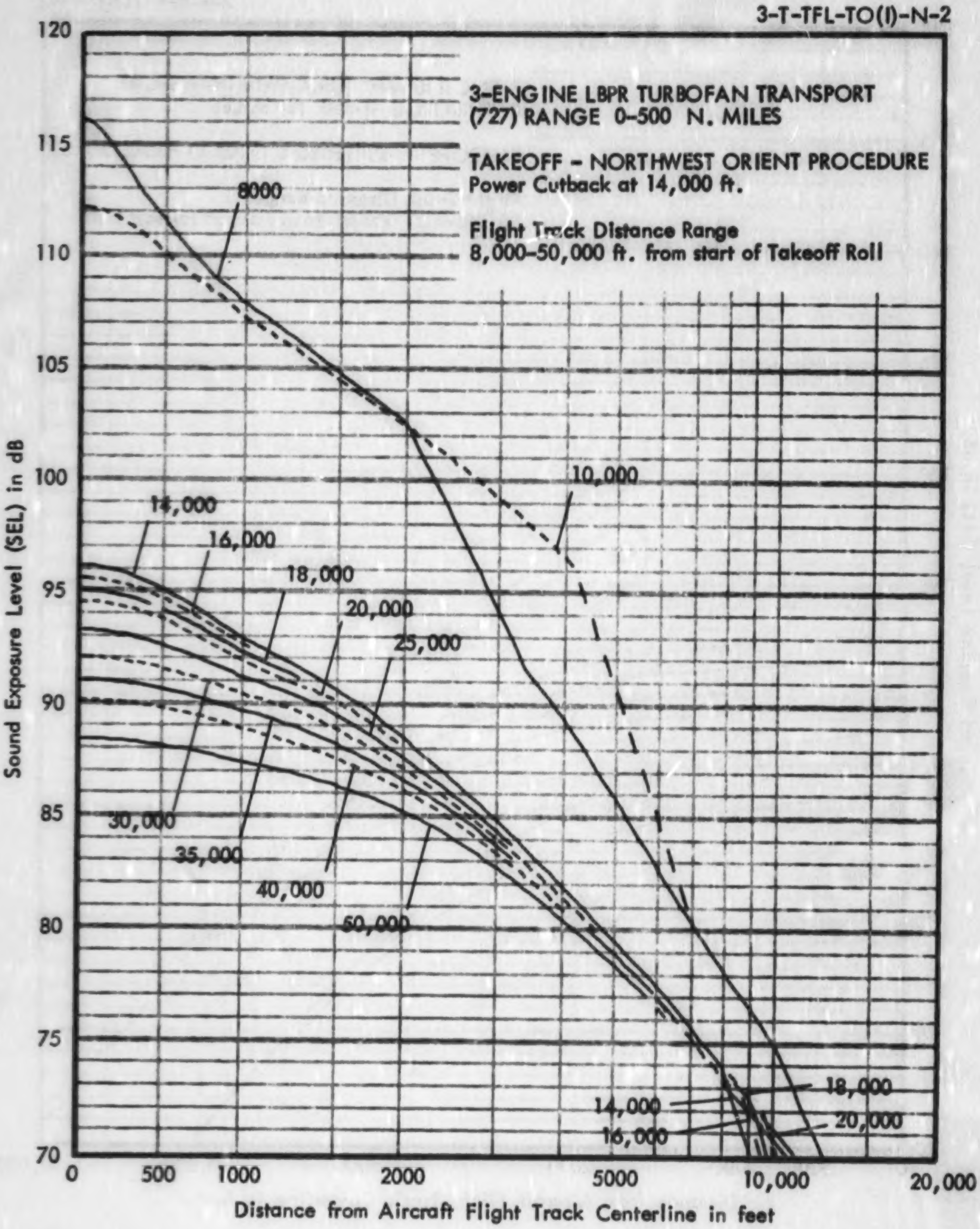

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE >500 N. MILES
TAKEOFF - ATA
Power Cutback at 22,000 ft.
Flight Track Distance Range
10,000-24,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
10,000
12,000
14,000
16,000
20,000
18,000
22,000
24,000

3-T-TFL-TO(II)-S-3

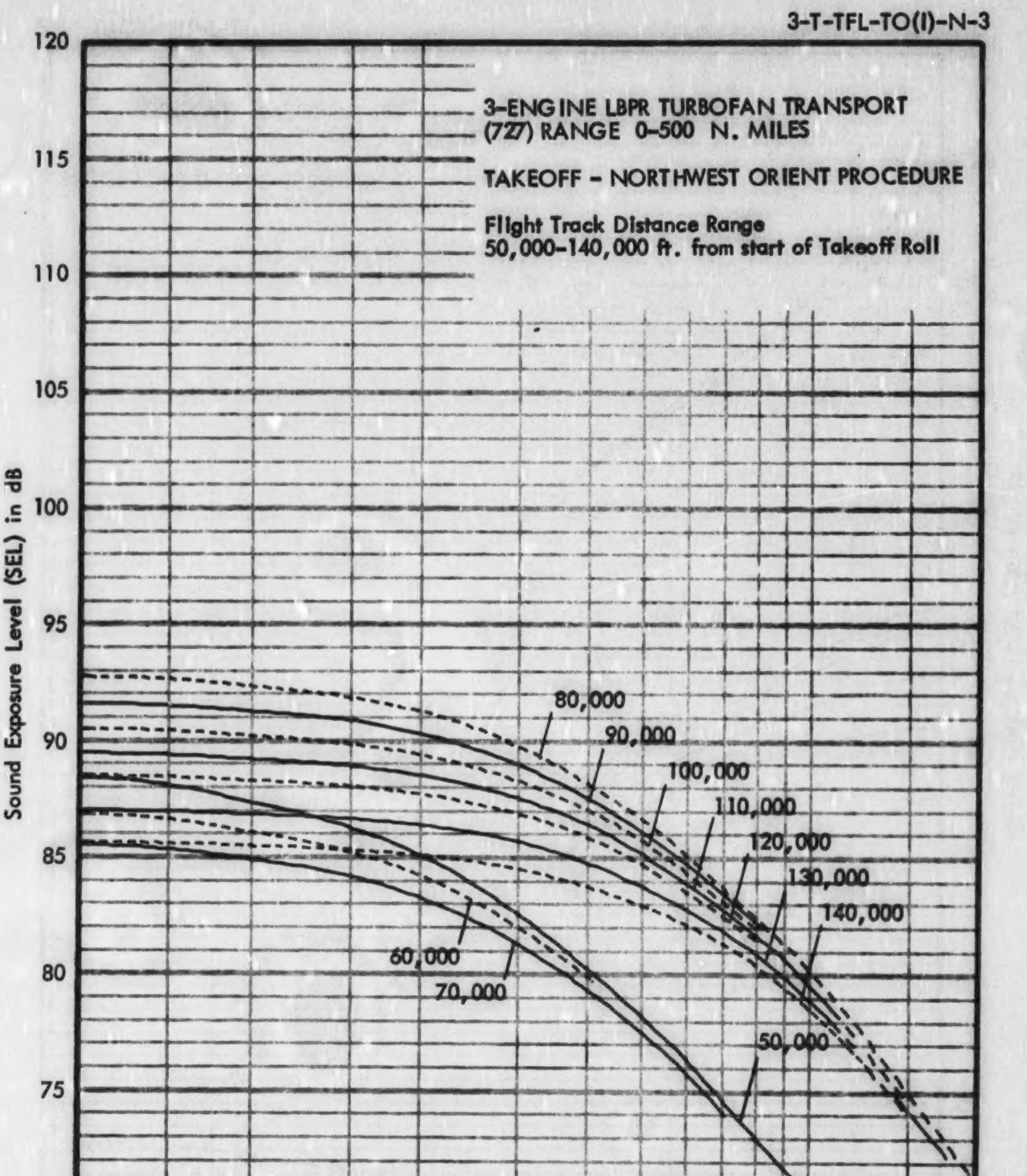


3-T-TFL-TO(I)-N-1

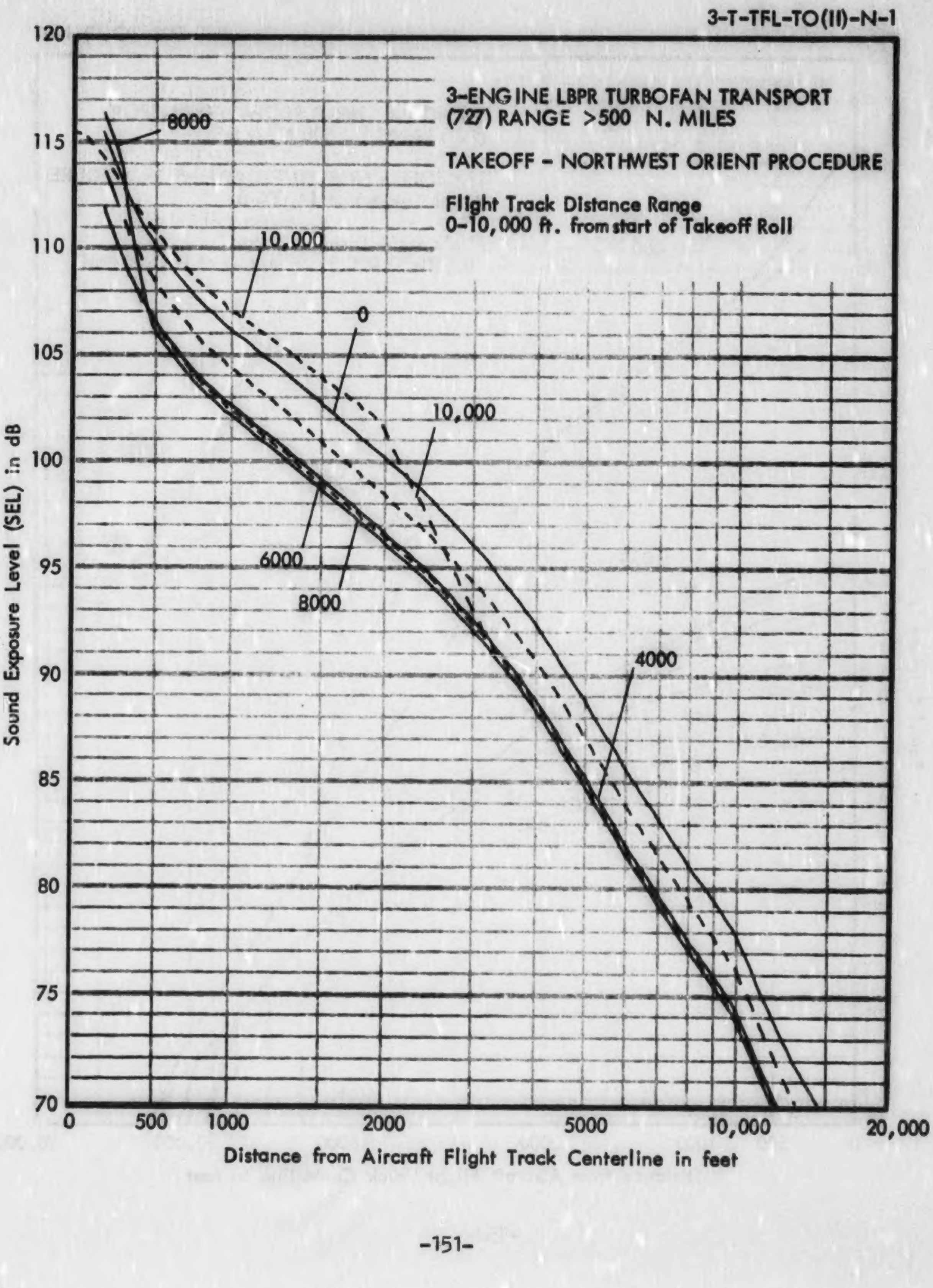

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

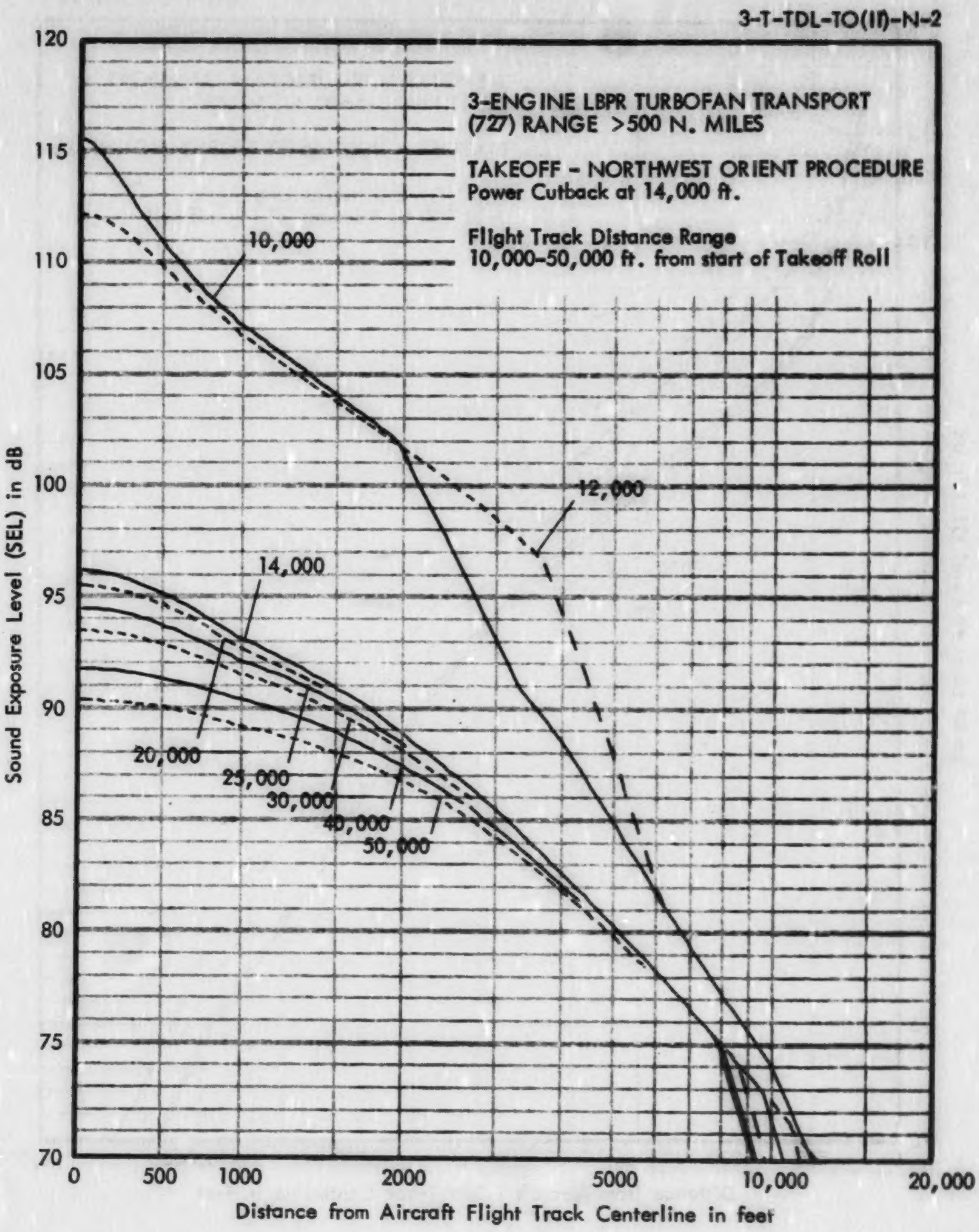

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 14,000 ft.
Flight Track Distance Range
8,000-50,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
8000
10,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000
18,000
14,000
20,000
16,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

3-T-TFL-TO(I)-N-3

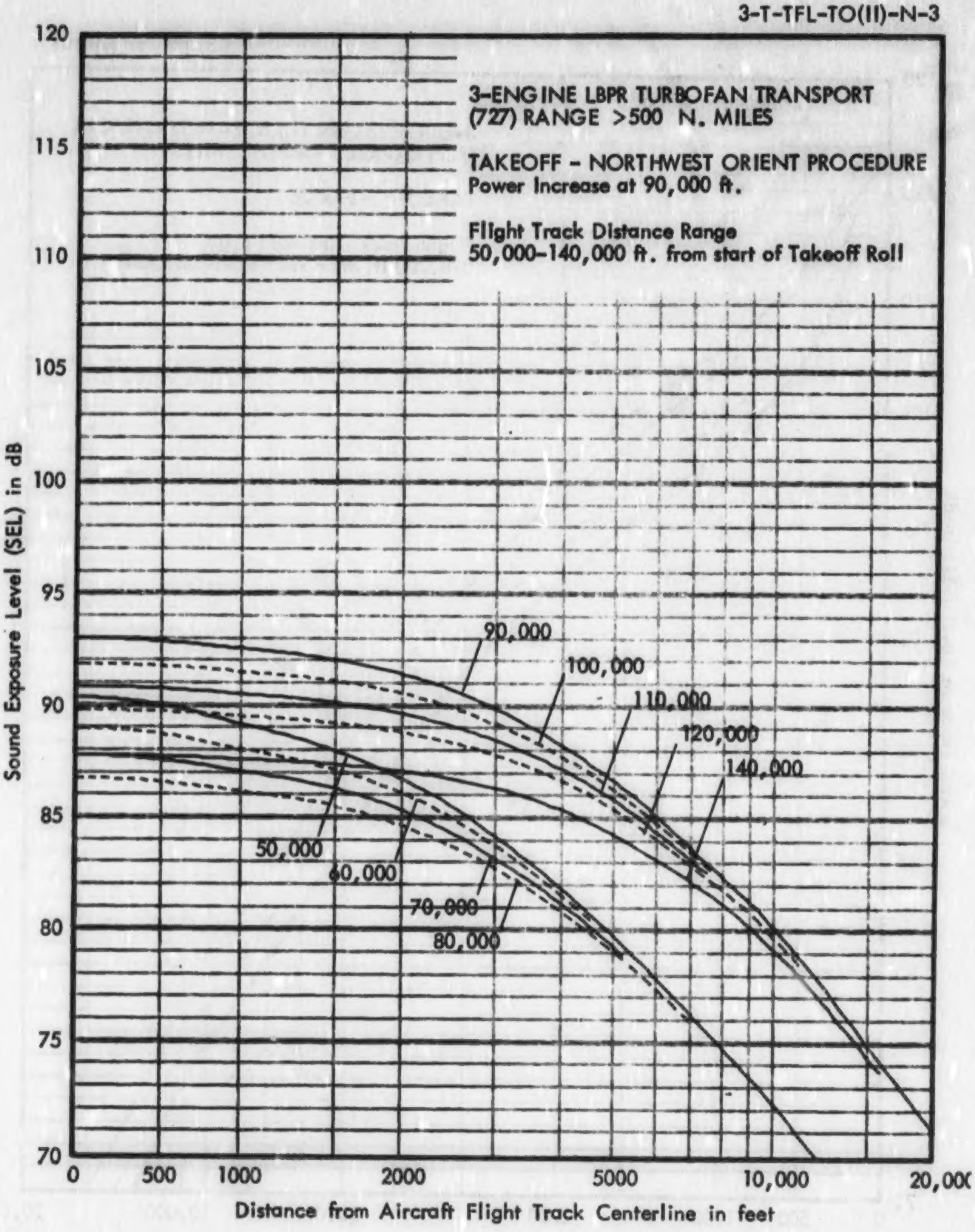

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
50,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
80,000
90,000
100,000
110,000
120,000
130,000
140,000
60,000
70,000
50,000

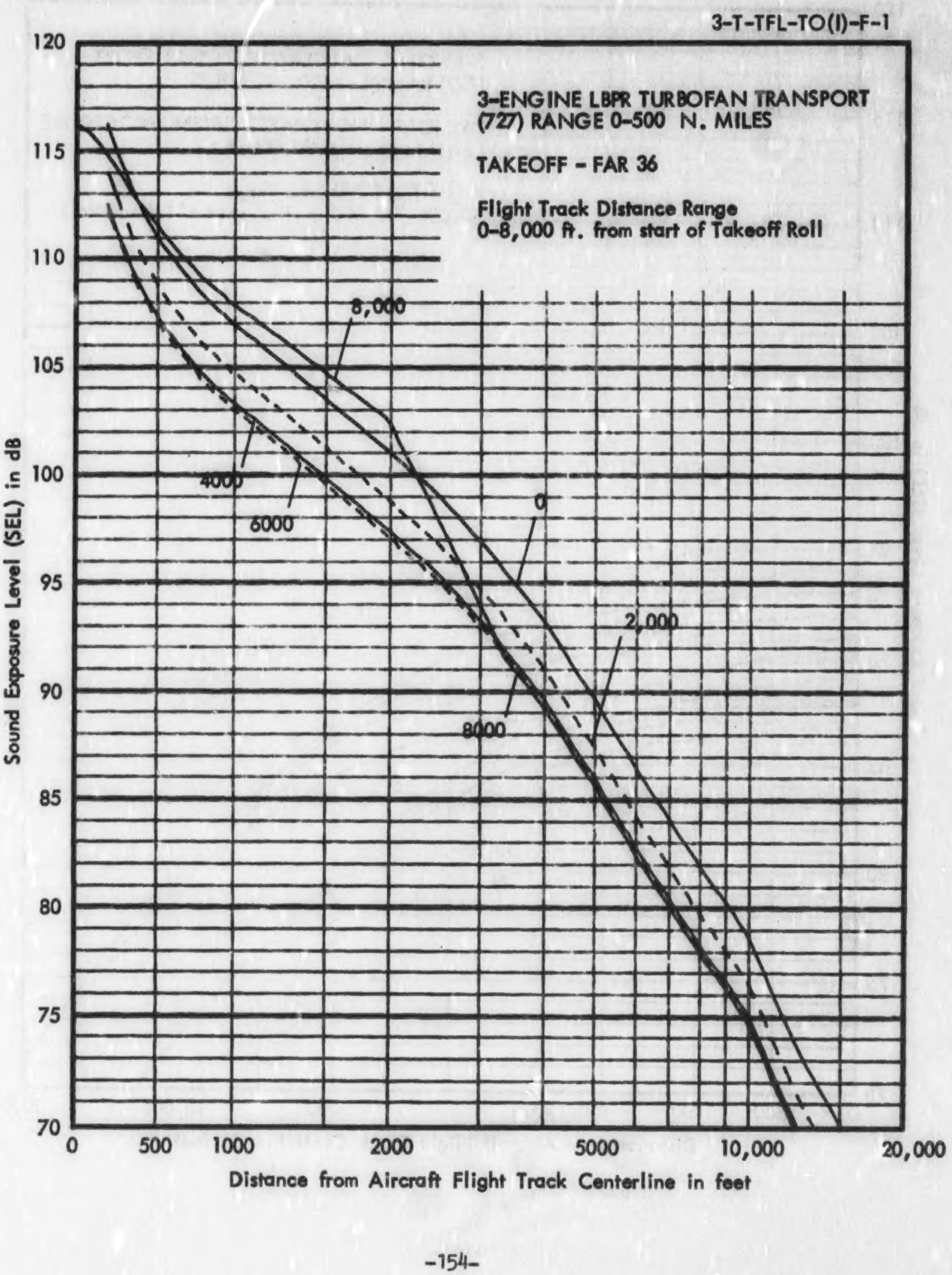
3-T-TFL-TO(II)-N-1

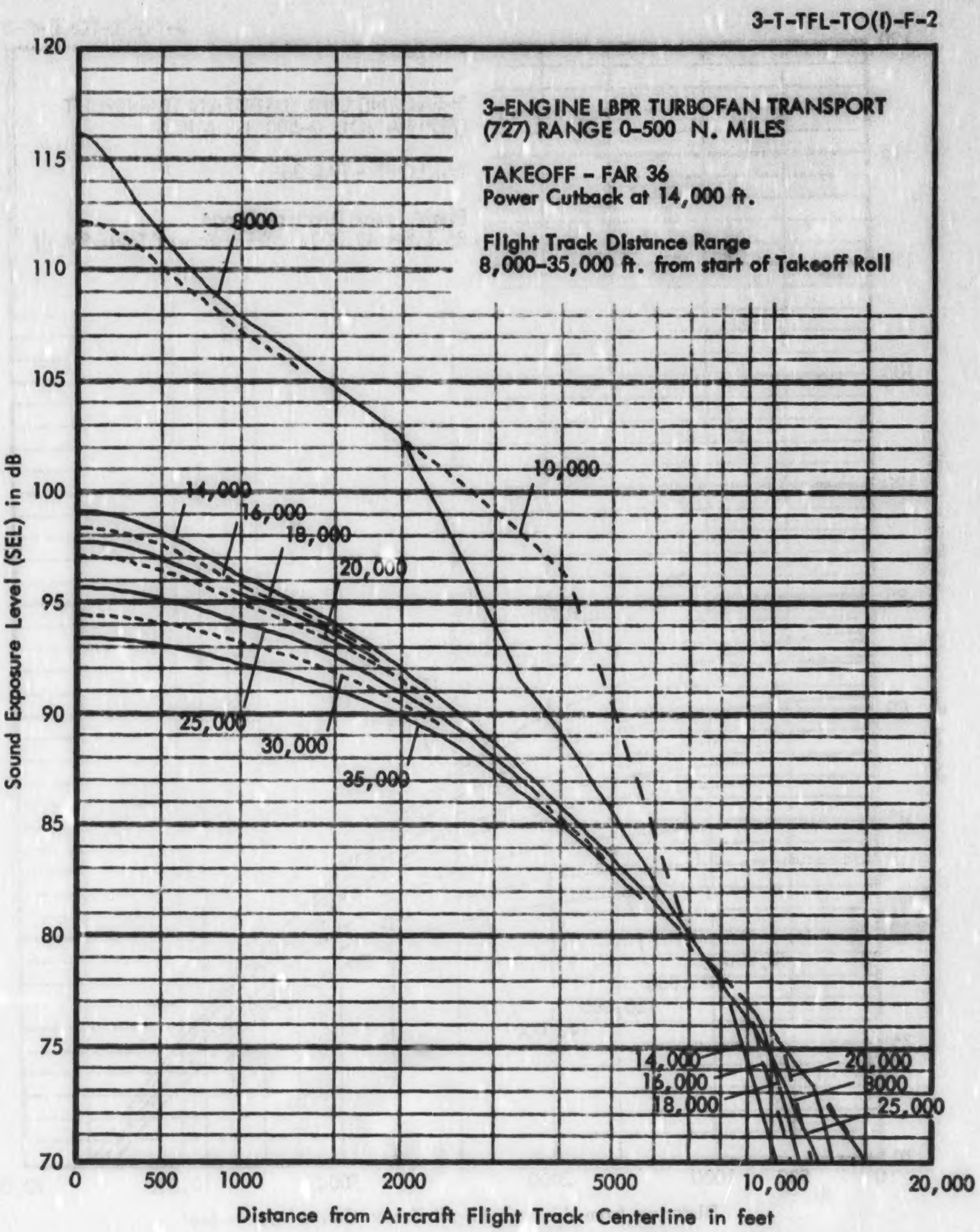


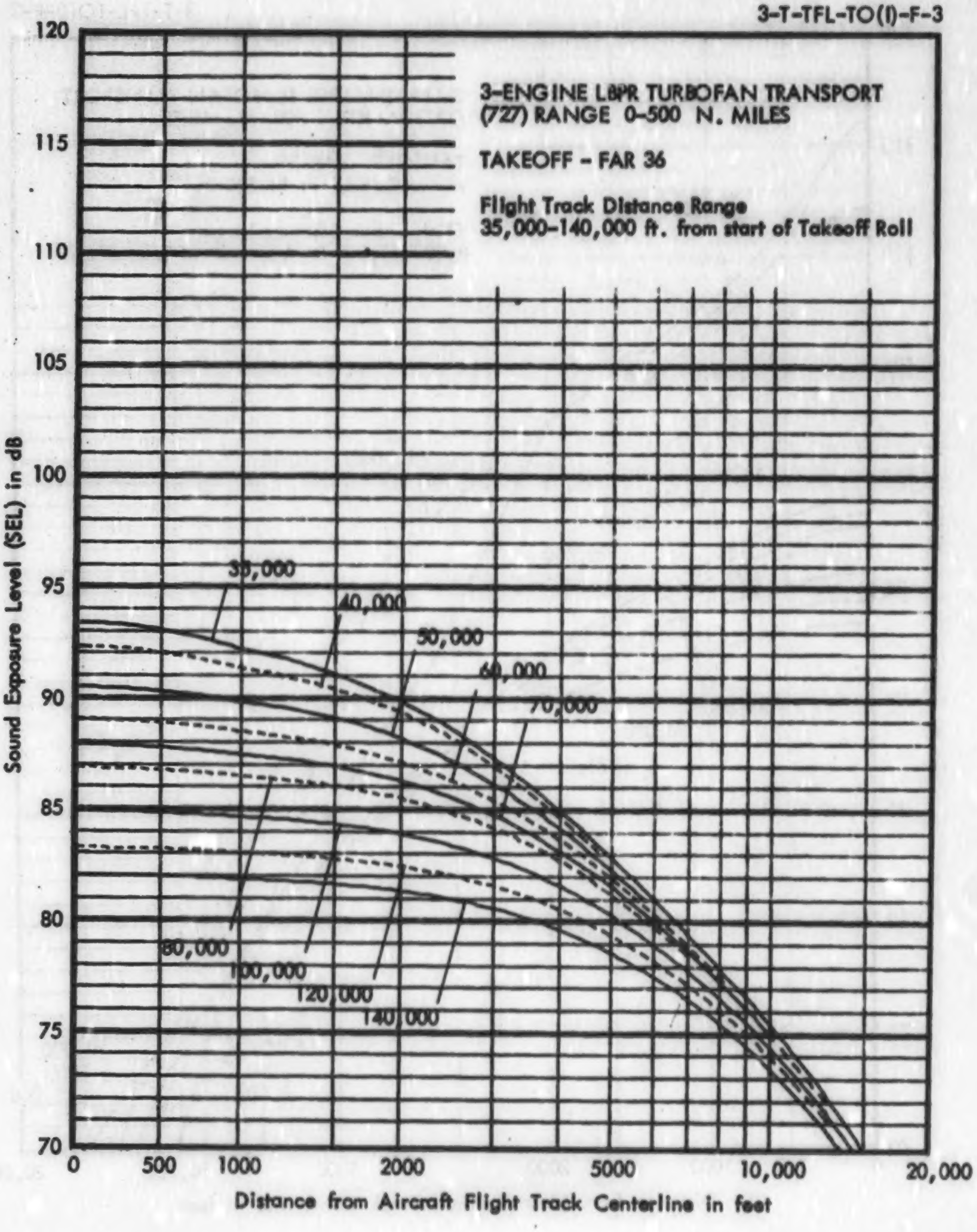

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE >500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 14,000 ft.
Flight Track Distance Range
10,000-50,000 ft. from start of Takeoff Roll
10,000
12,000
14,000
20,000
25,000
30,000
40,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

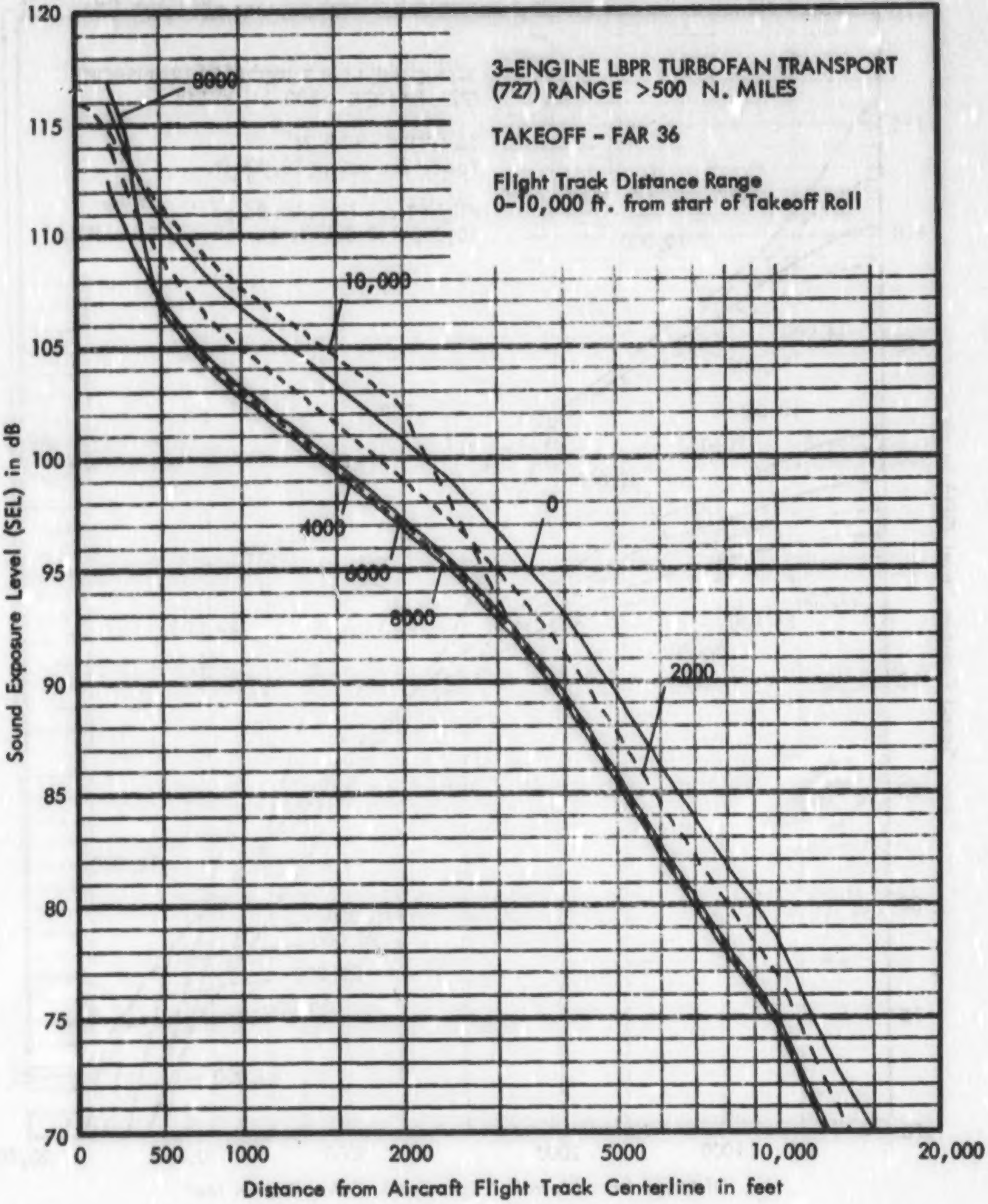
3-T-TFL-TO(II)-N-3

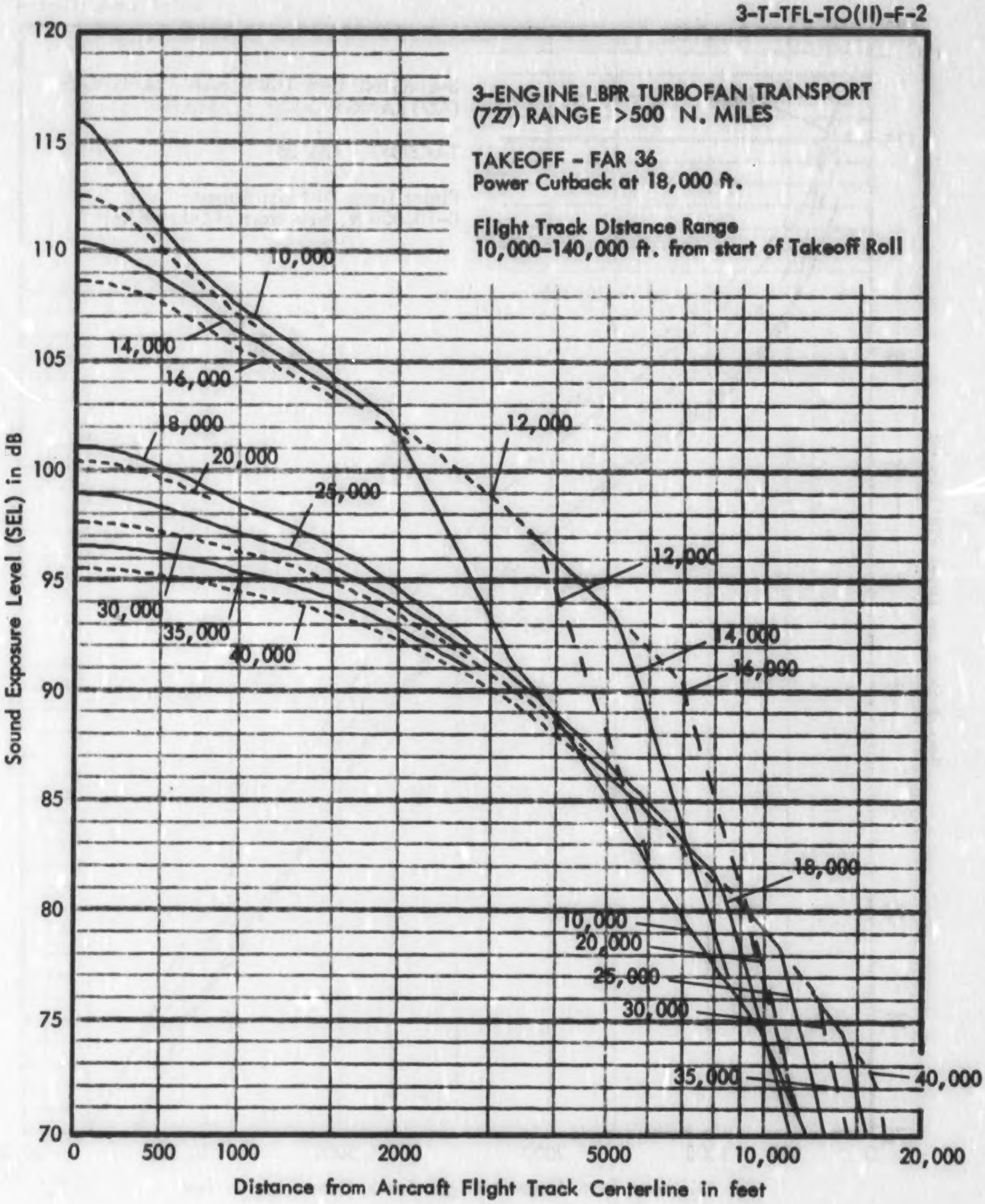



3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8,000
4000
6000
0
2,000
8000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Power Cutback at 14,000 ft.
Flight Track Distance Range
8,000-35,000 ft. from start of Takeoff Roll
8000
10,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
14,000
16,000
18,000
20,000
8000
25,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
35,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
50,000
60,000
70,000
80,000
100,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE >500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
8000
10,000
0
4000
6000
8000
2000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE >500 N. MILES
TAKEOFF - FAR 36
Power Cutback at 18,000 ft.
Flight Track Distance Range
10,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
10,000
14,000
16,000
12,000
18,000
20,000
25,000
30,000
35,000
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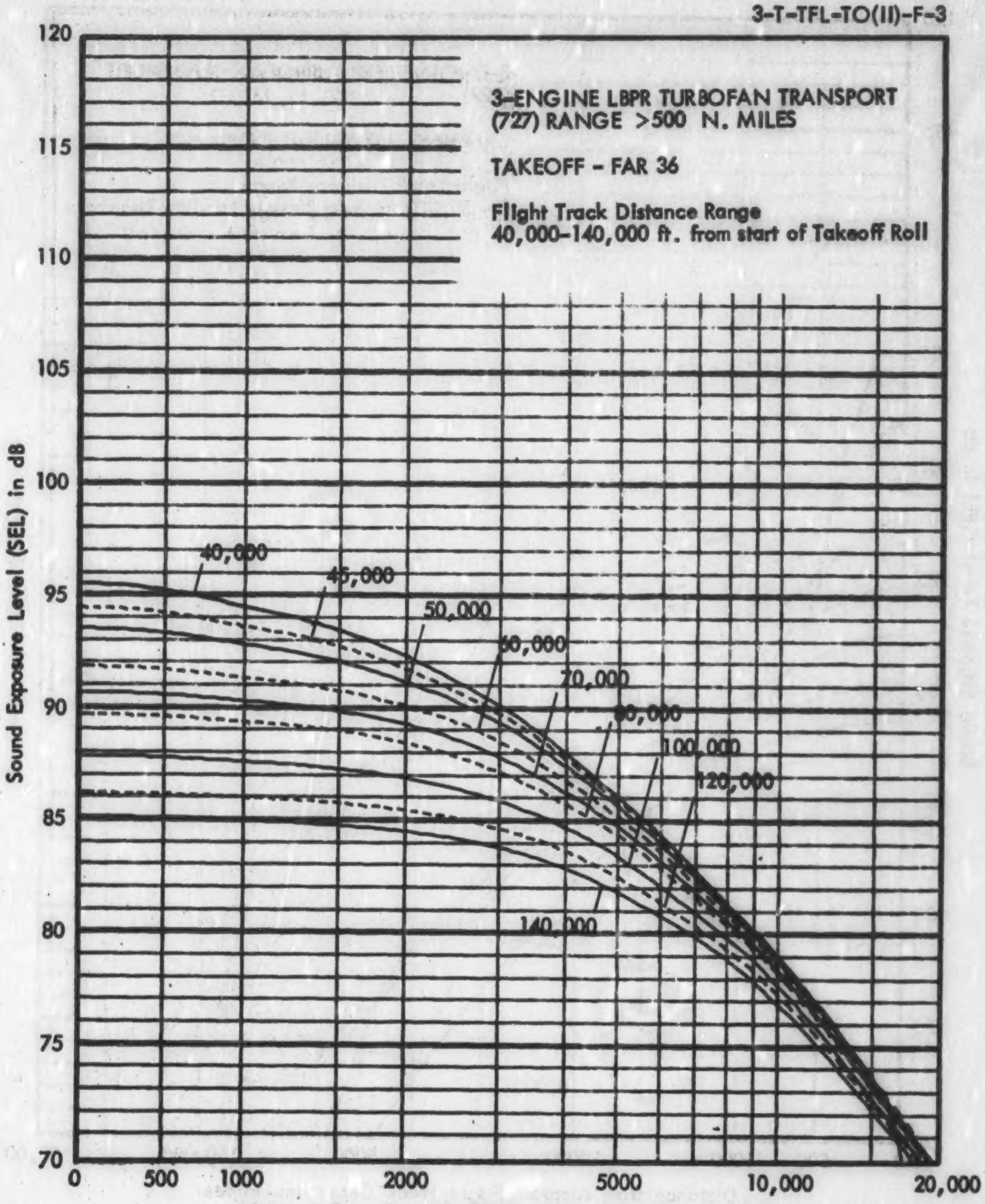
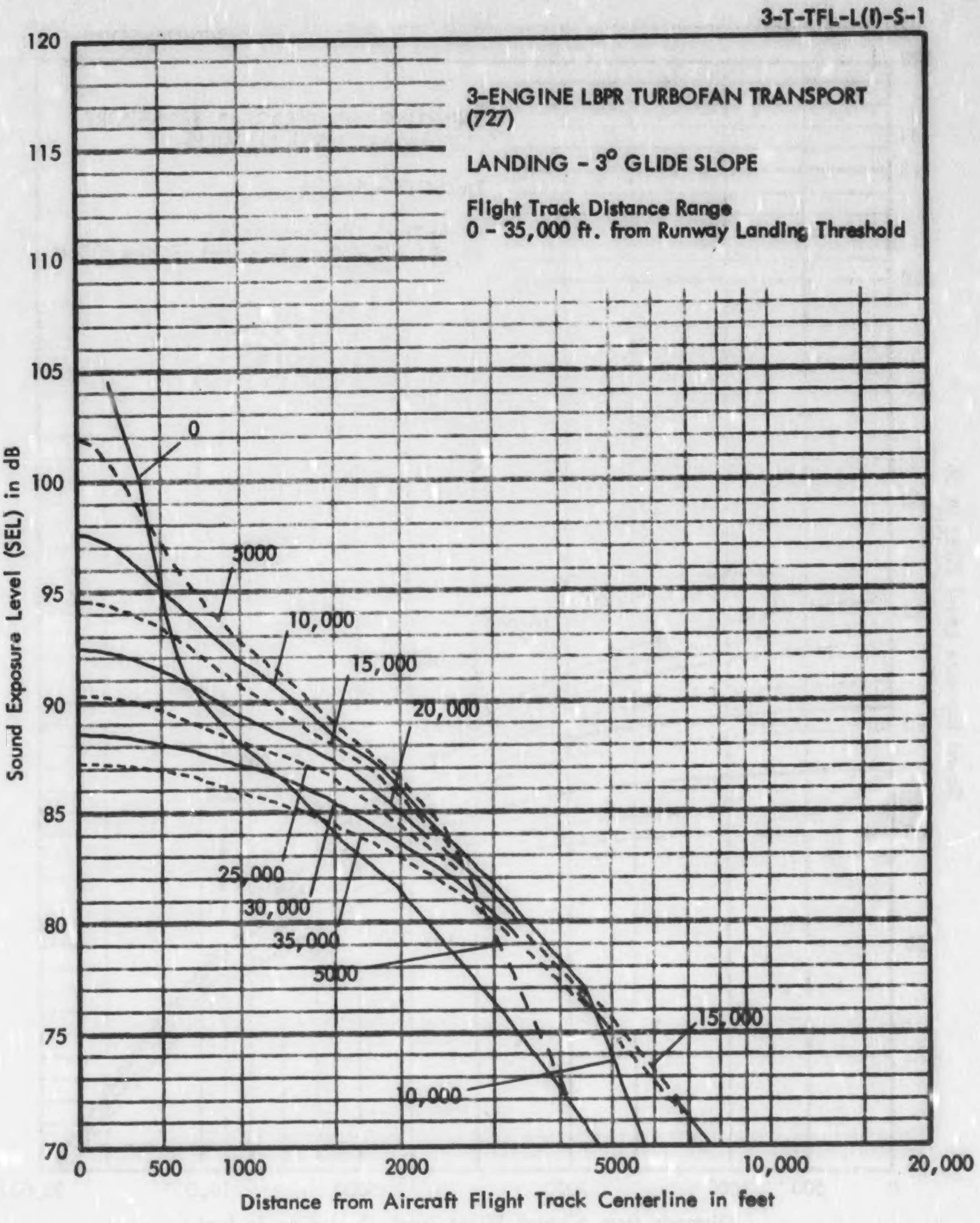
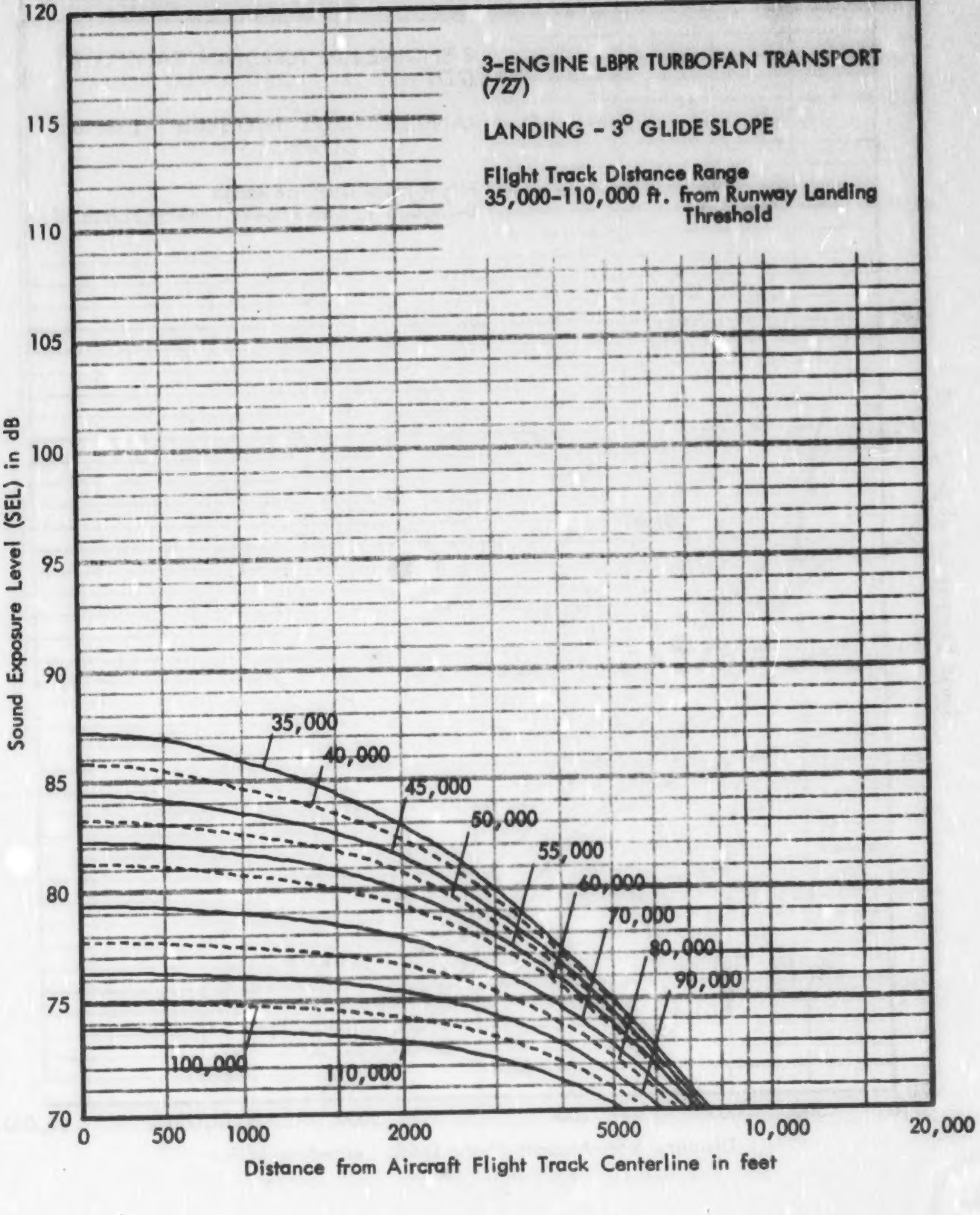
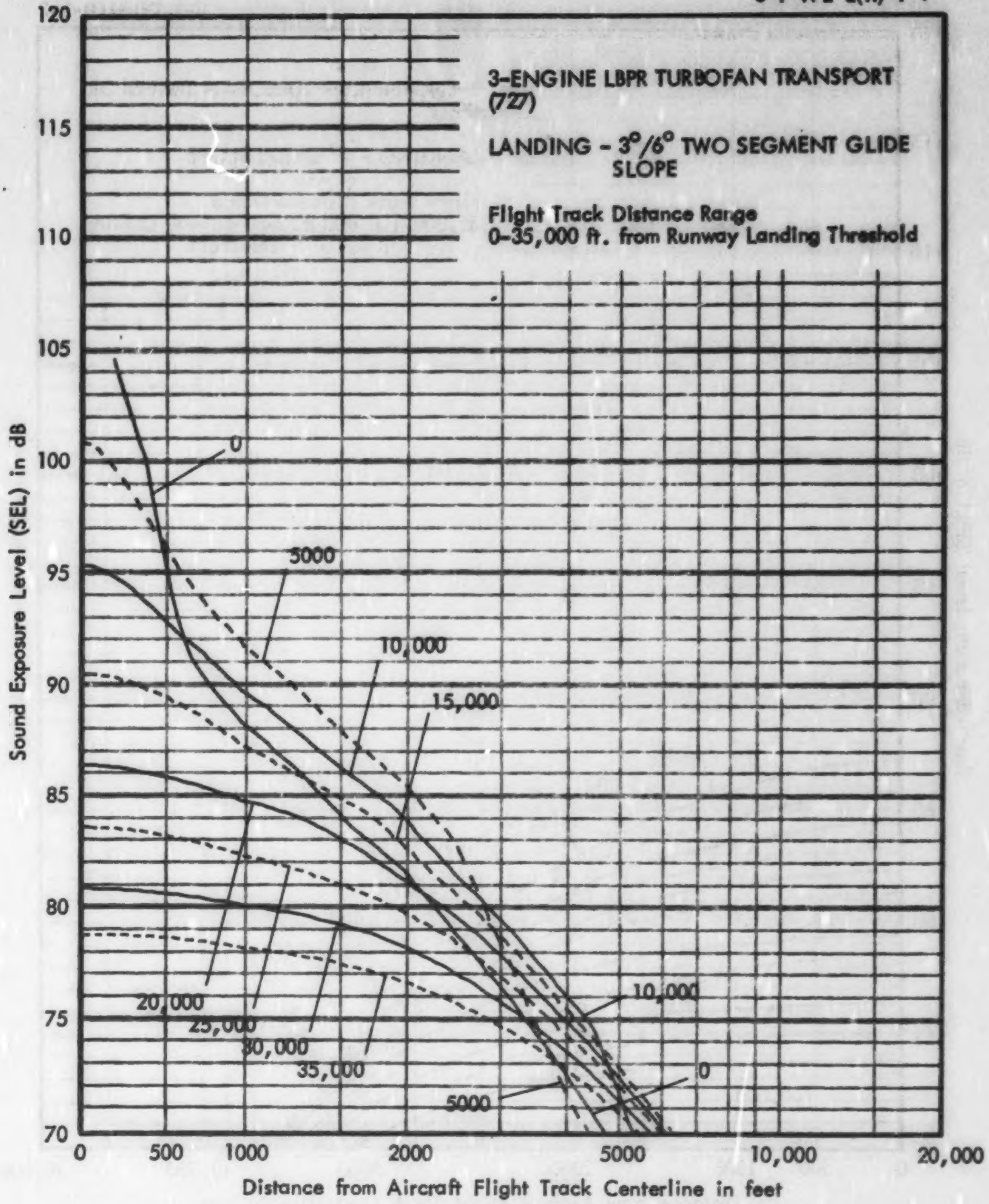
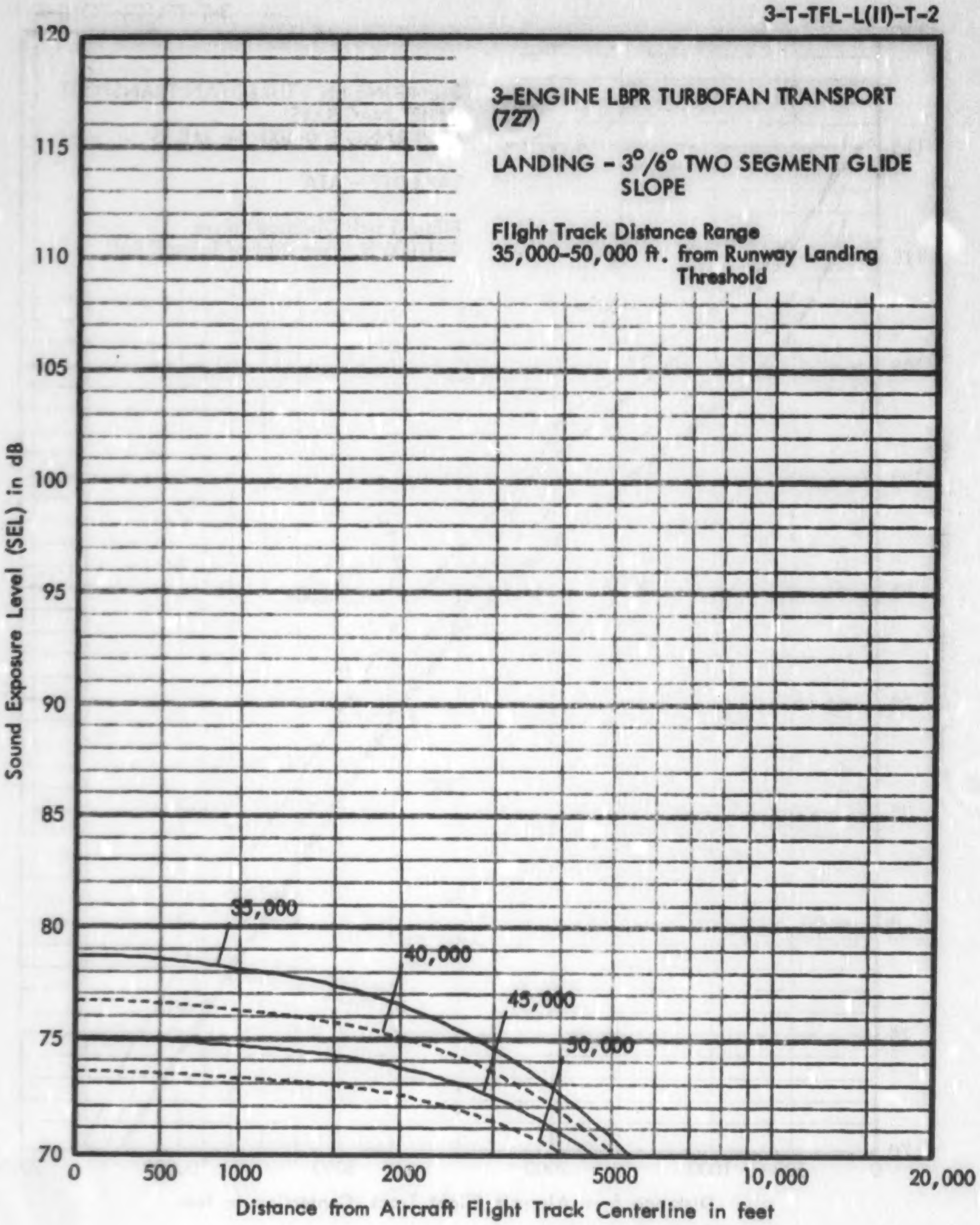
20,000
25,000
30,000
35,000
40,000

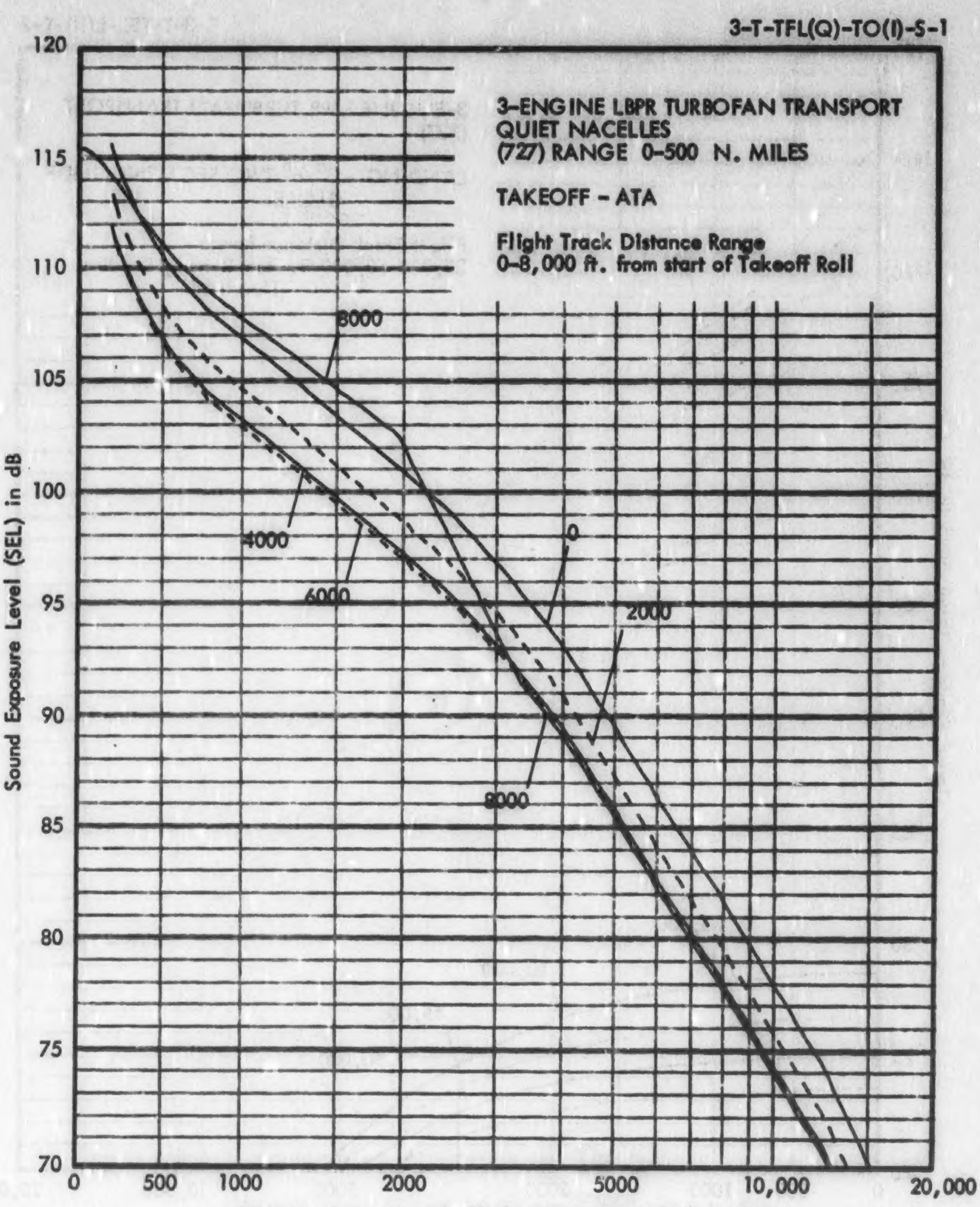

3-ENGINE LBPR TURBOFAN TRANSPORT
(727) RANGE >500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll
40,000
45,000
50,000
60,000
70,000
80,000
100,000
120,000
140,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT (727)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0 - 35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
5000
15,000
10,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

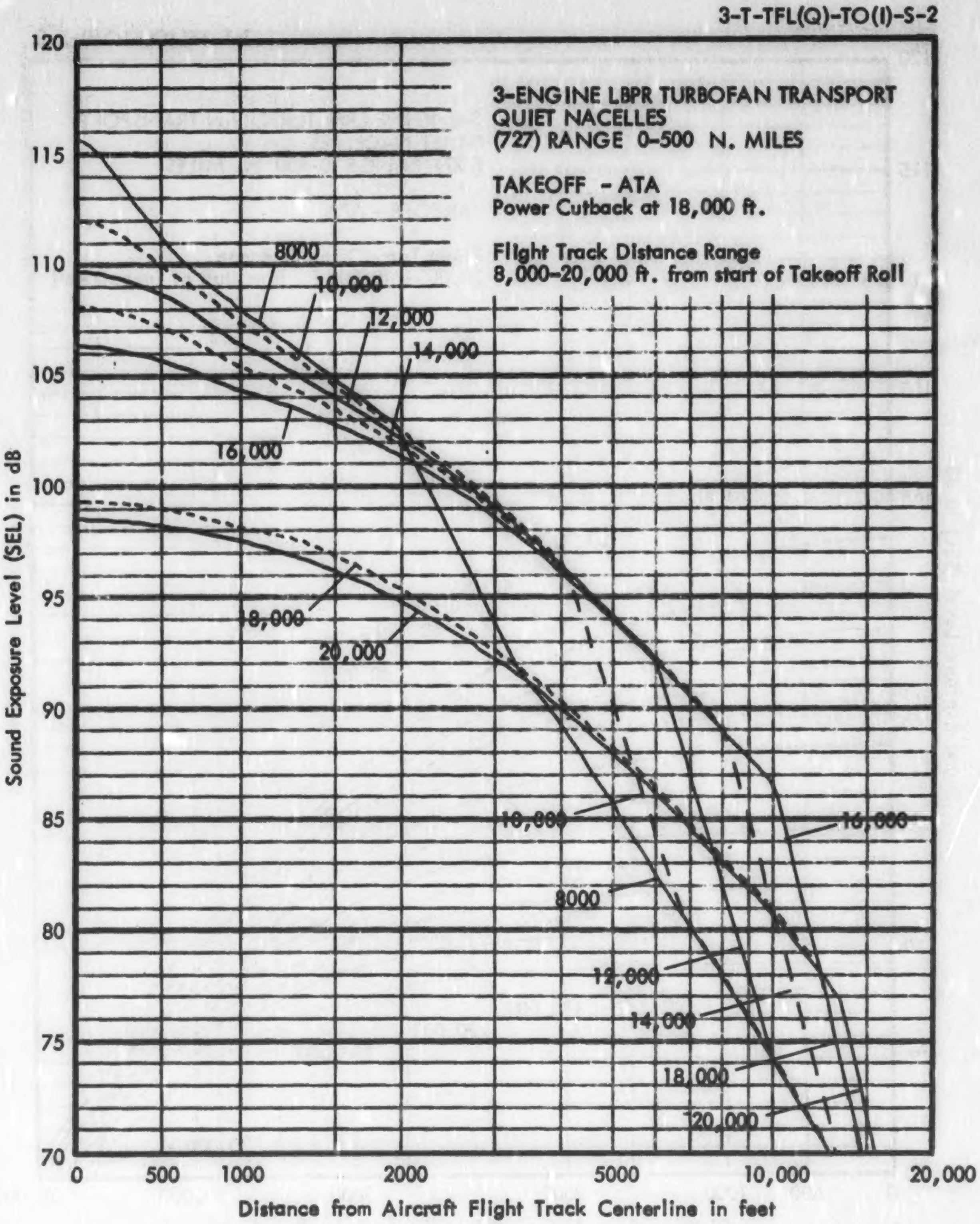

3-ENGINE LBPR TURBOFAN TRANSPORT
(727)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
35,000-110,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
50,000
55,000
60,000
70,000
80,000
90,000
100,000
110,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT (727)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
10,000
0
5000

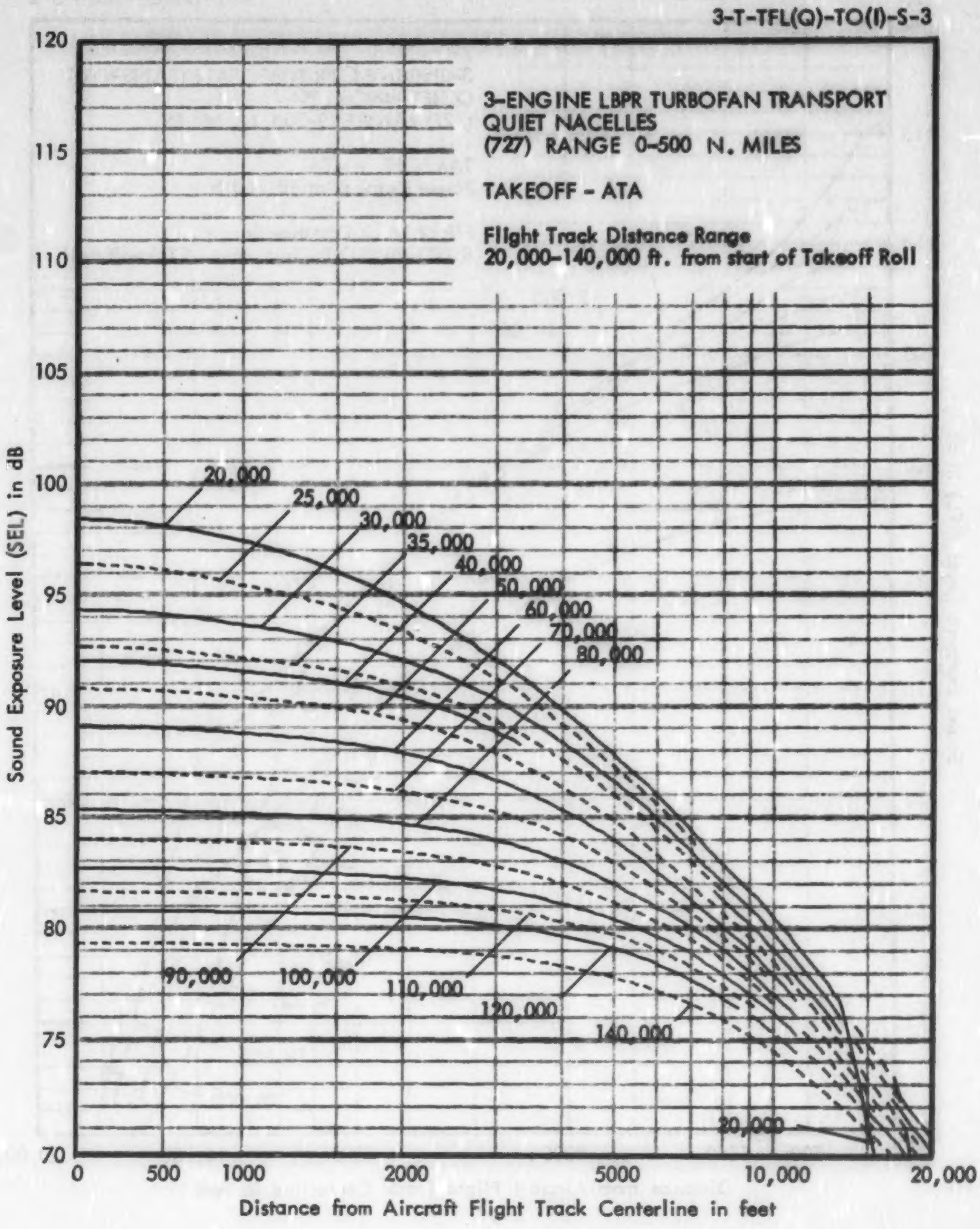

3-ENGINE LBPR TURBOFAN TRANSPORT (727)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range 35,000-50,000 ft. from Runway Landing Threshold
35,000
40,000
45,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

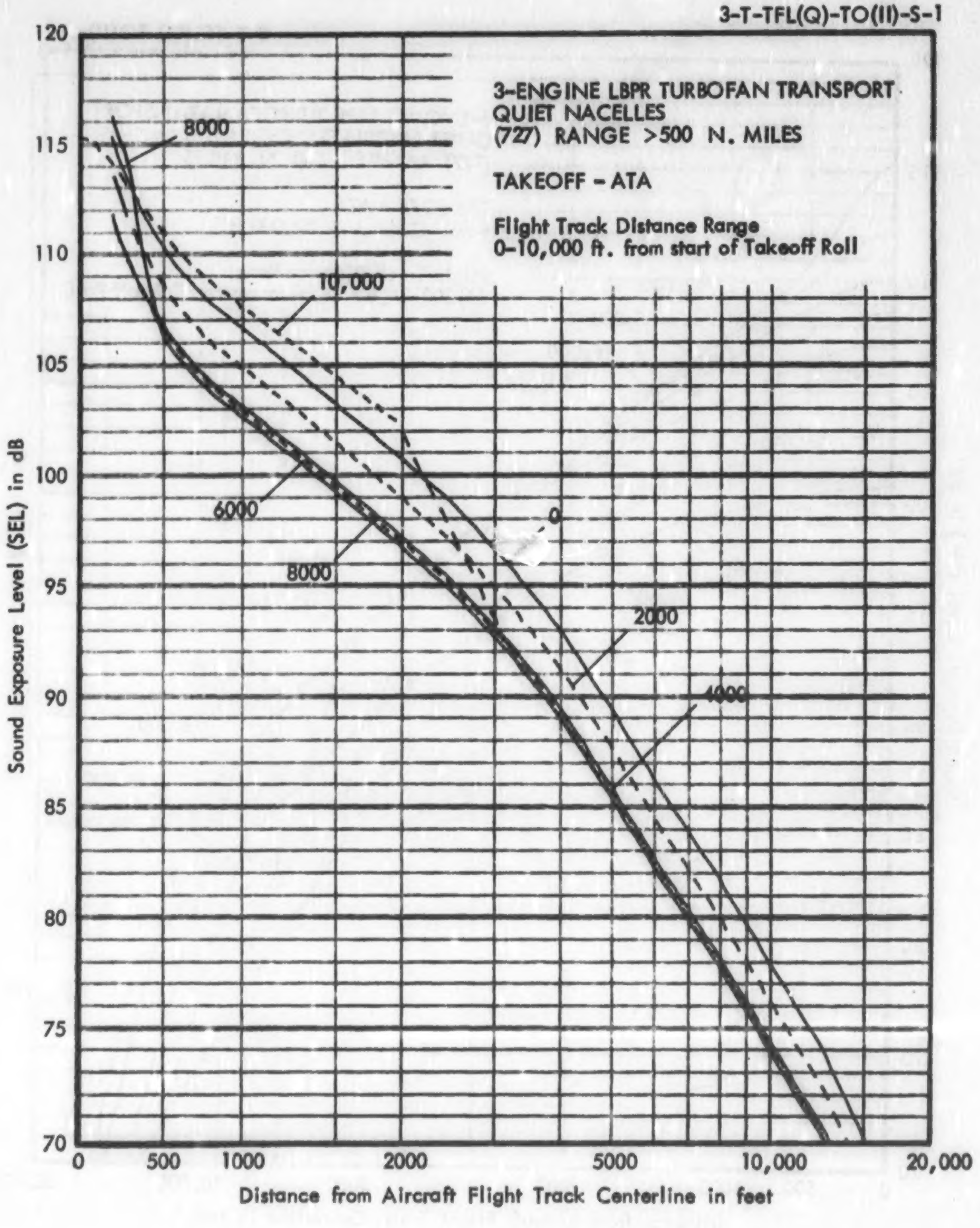

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE 0-500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
8000
4000
6000
0
2000
8000

3-T-TFL(Q)-TO(I)-S-2

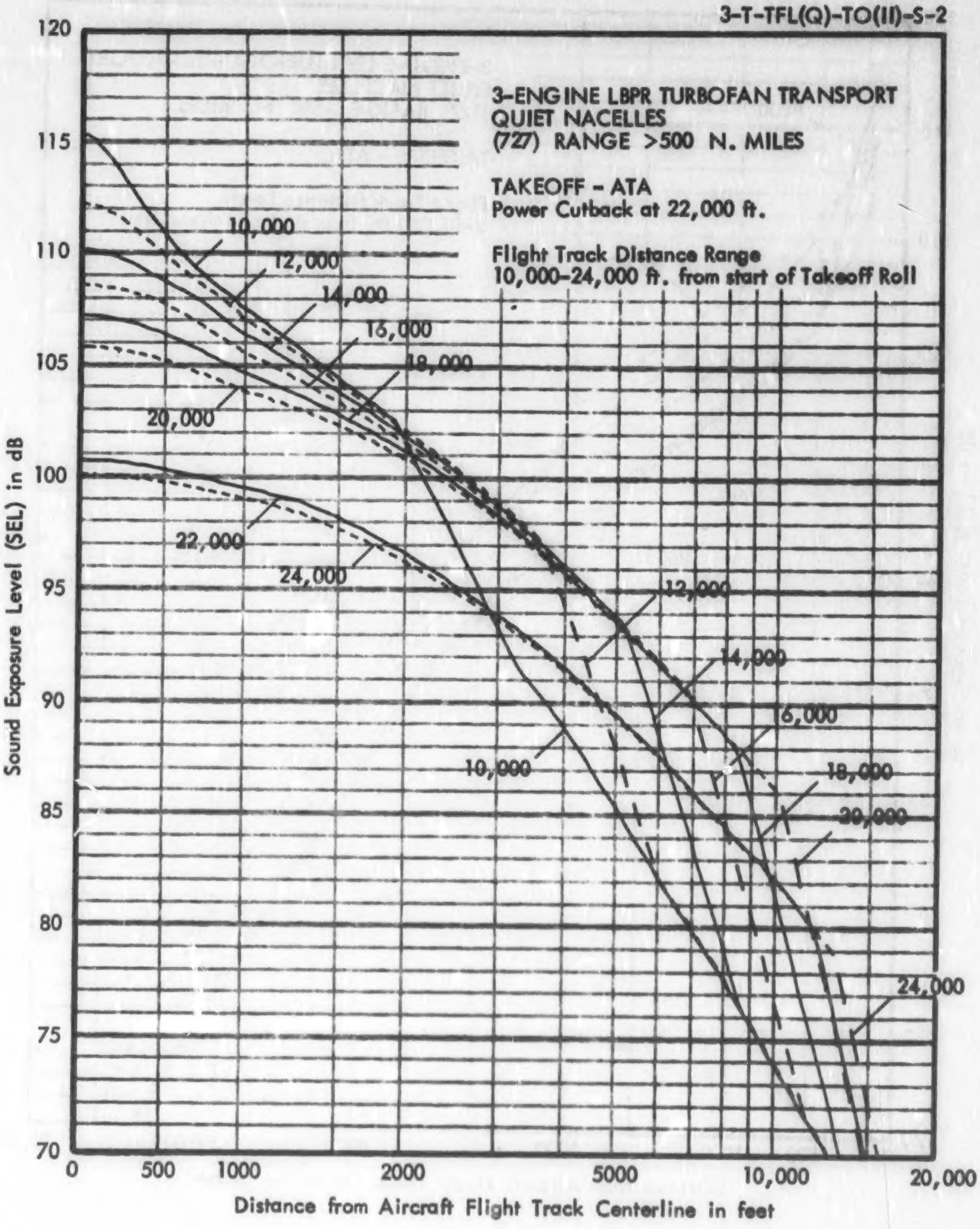


3-T-TFL(Q)-TO(I)-S-3

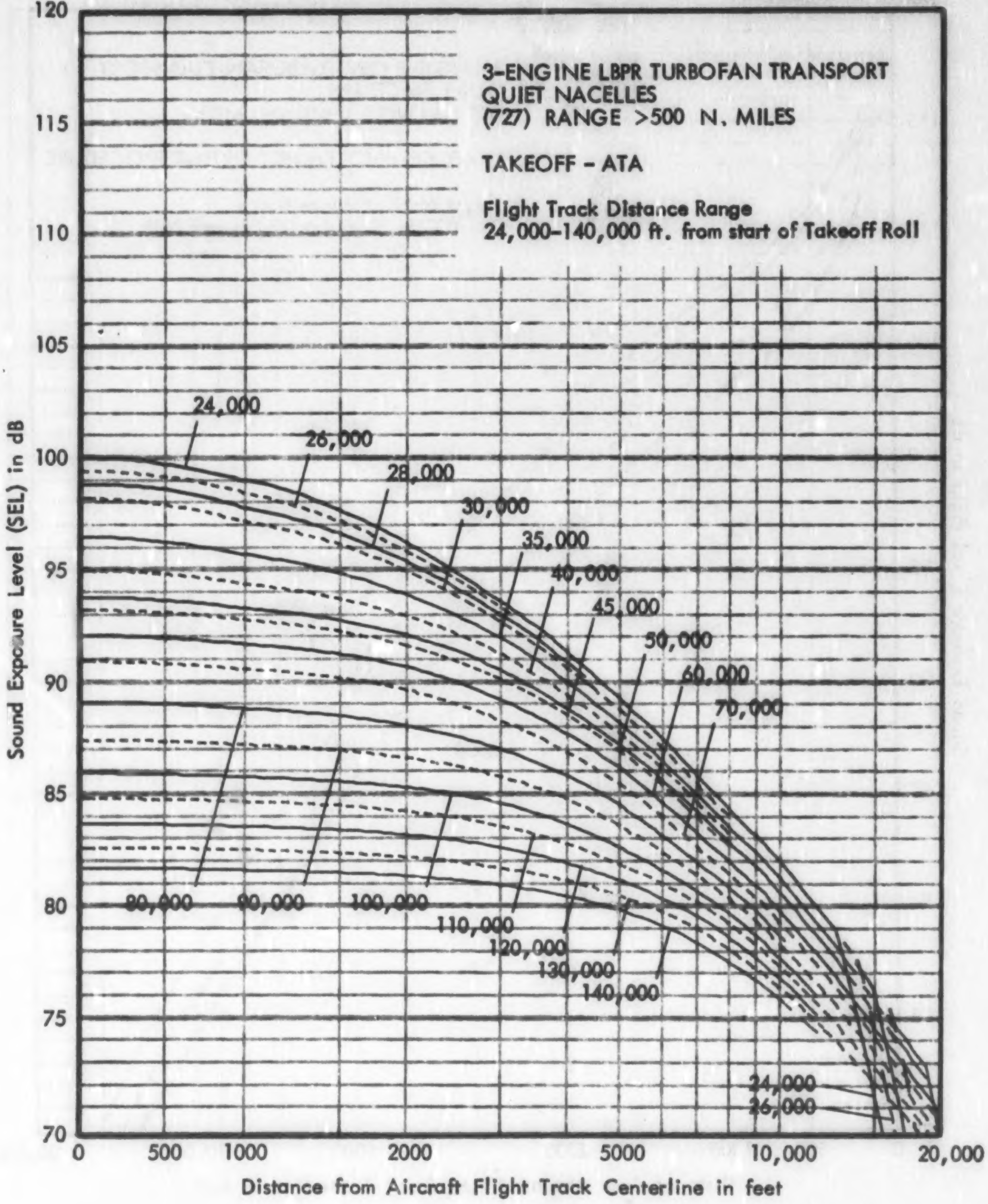


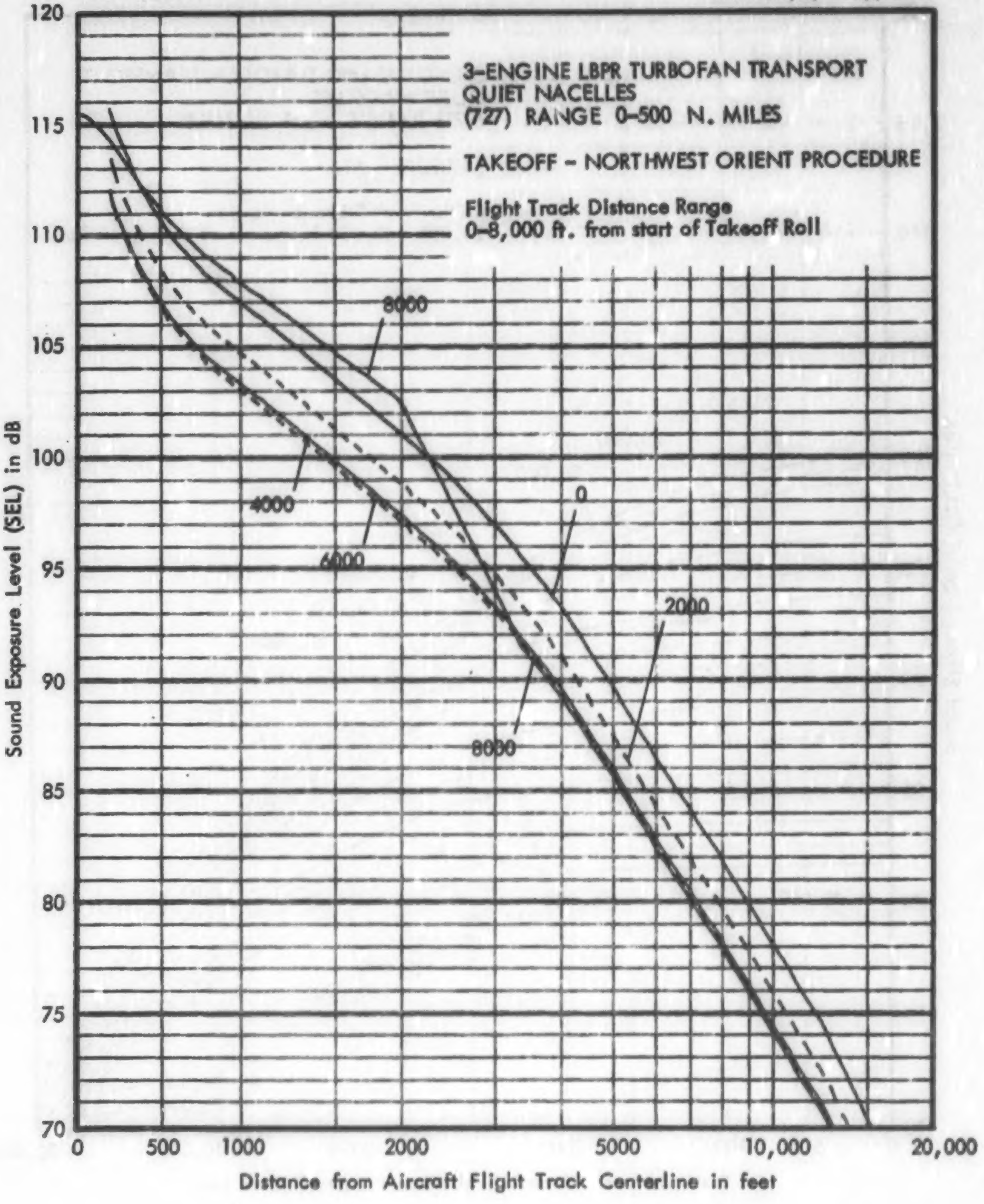

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE >500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
8000
10,000
6000
8000
0
2000
4000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

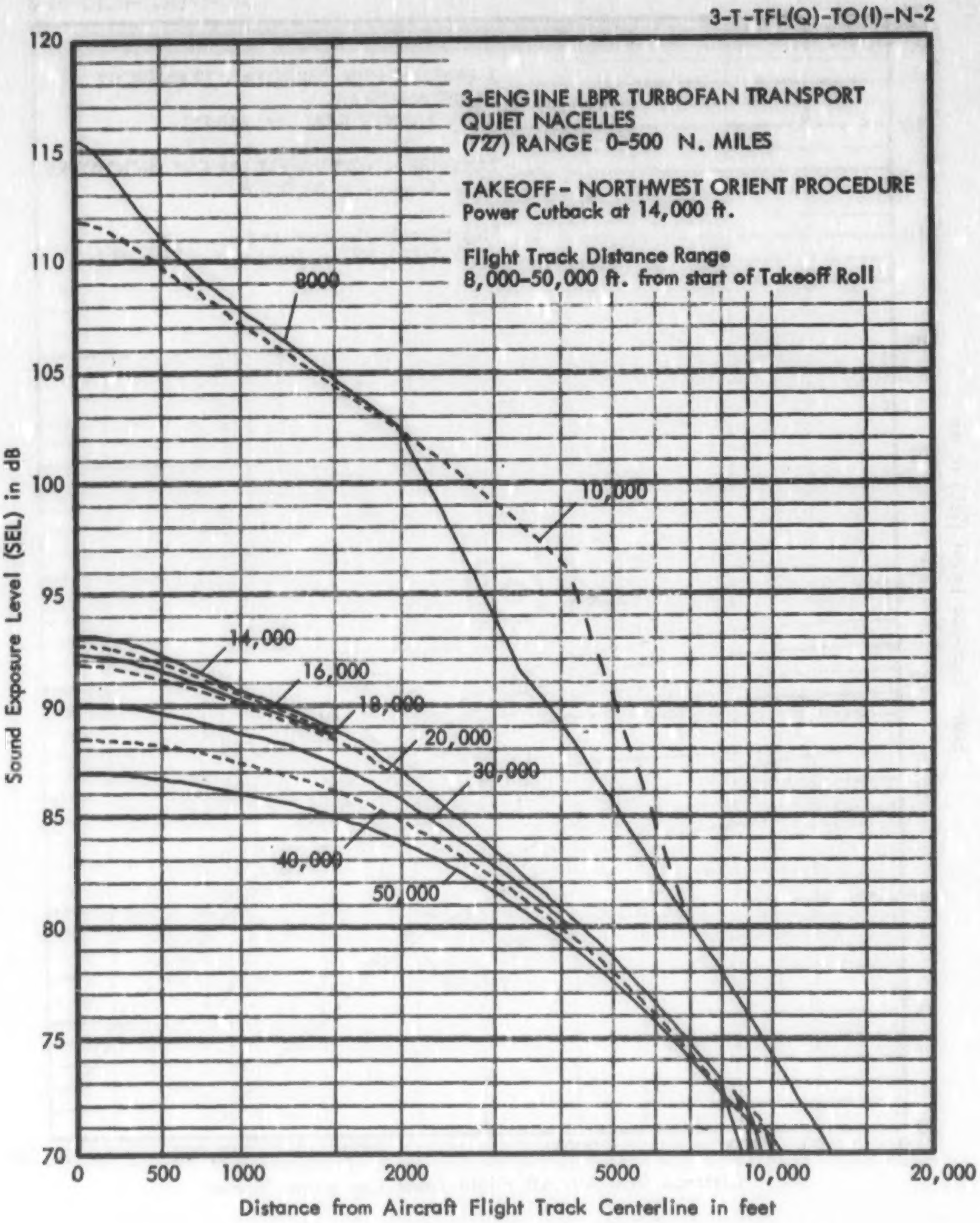
3-T-TFL(Q)-TO(II)-S-2



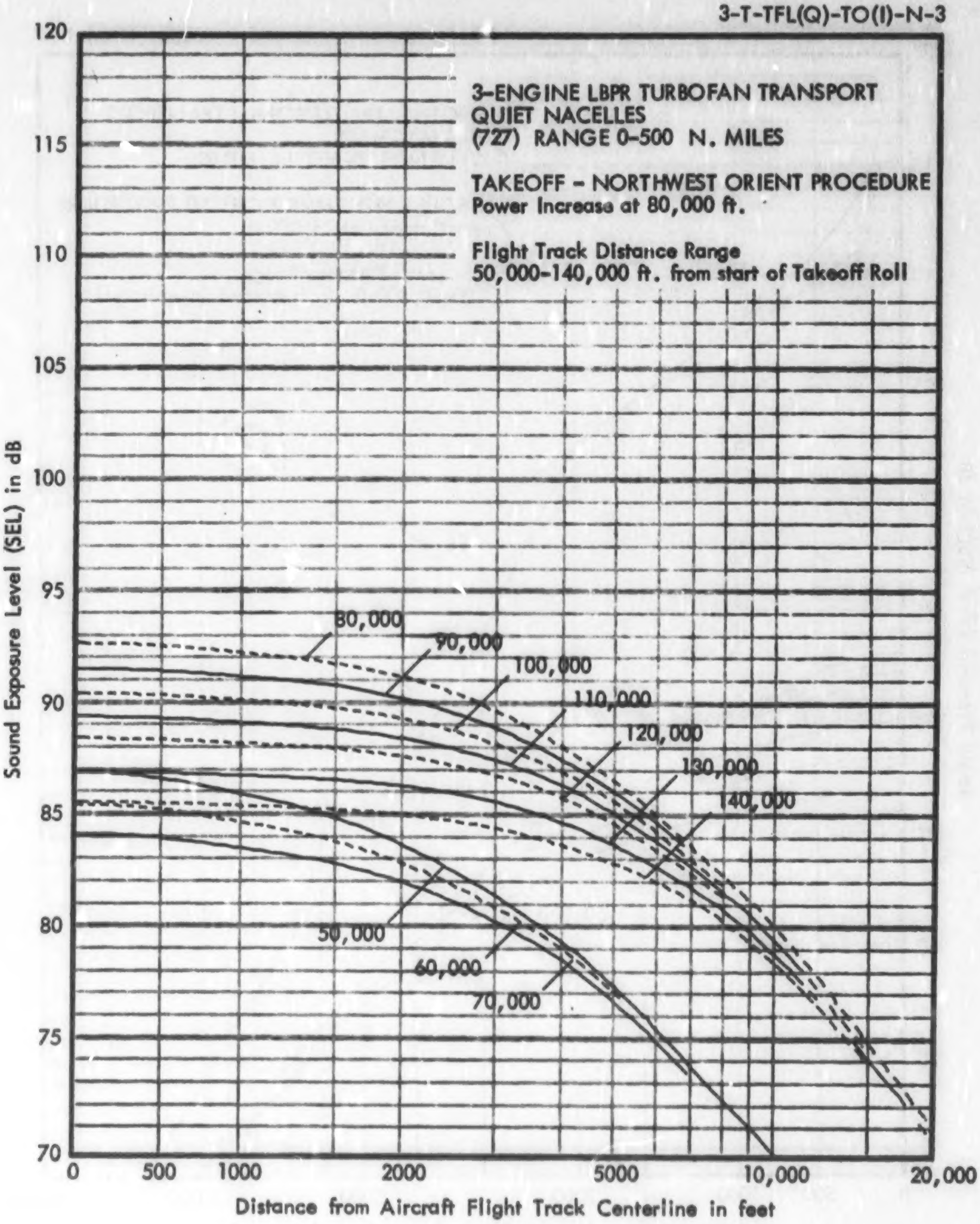
3-T-TFL(Q)-T(II)-S-3

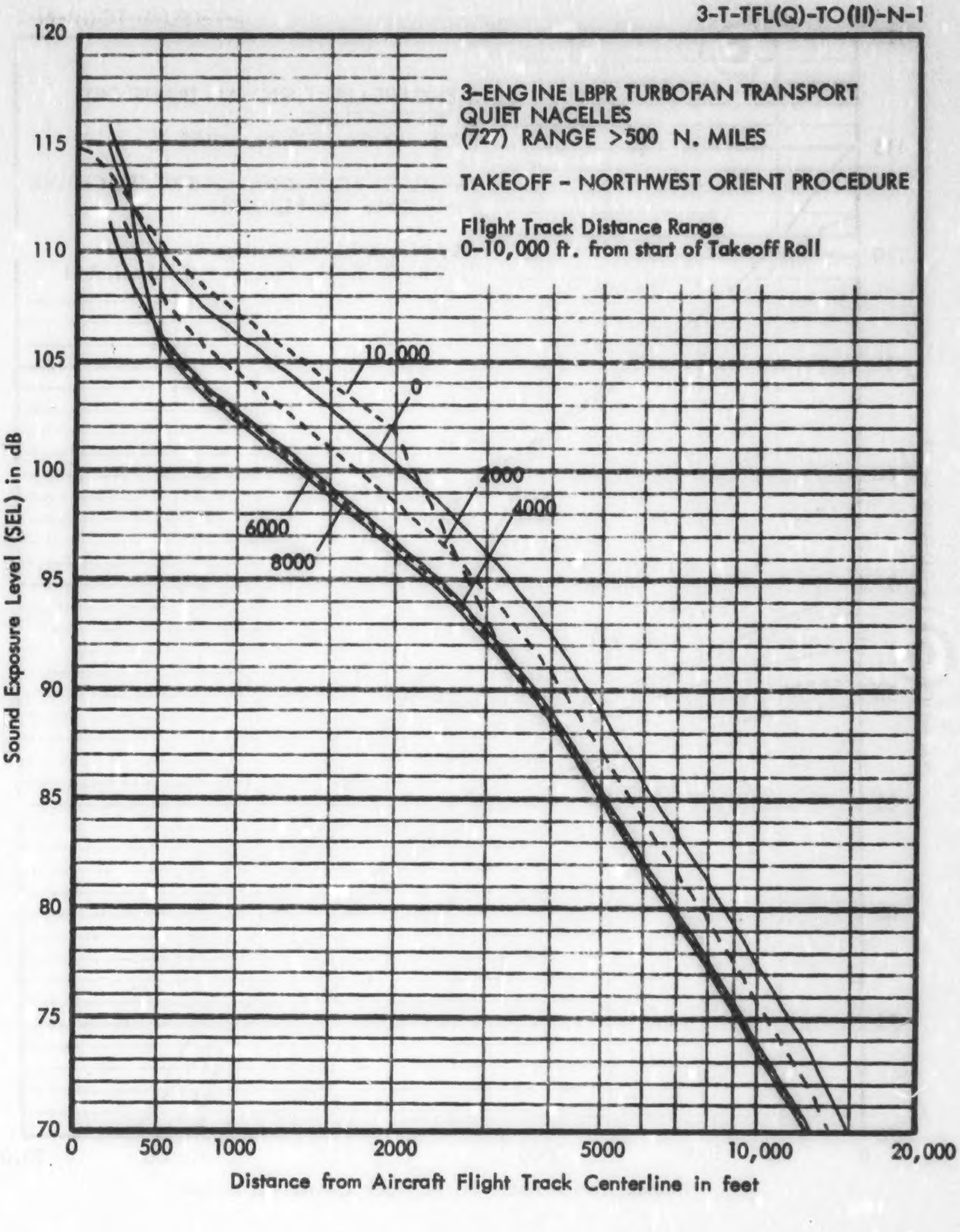


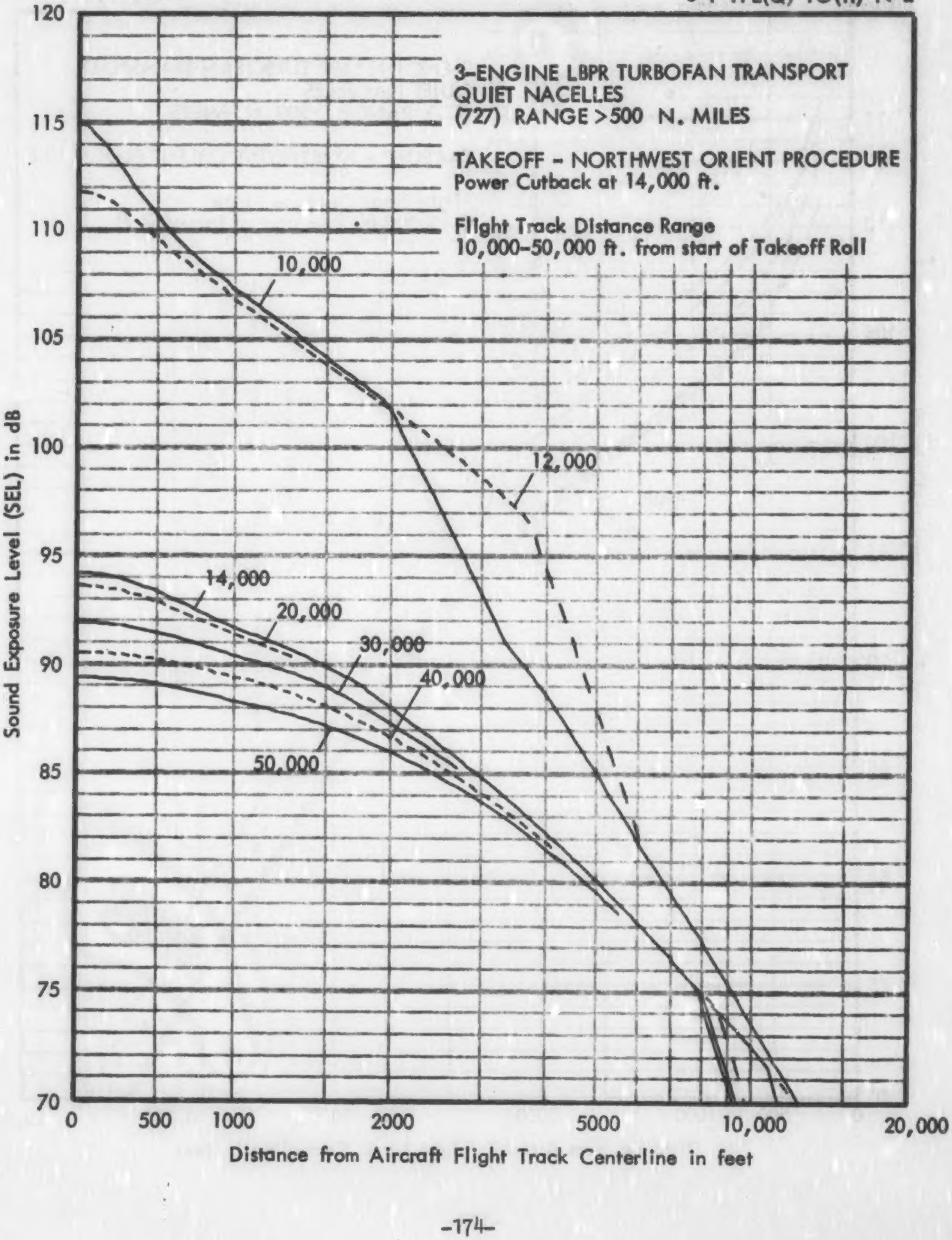

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
4000
6000
0
2000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

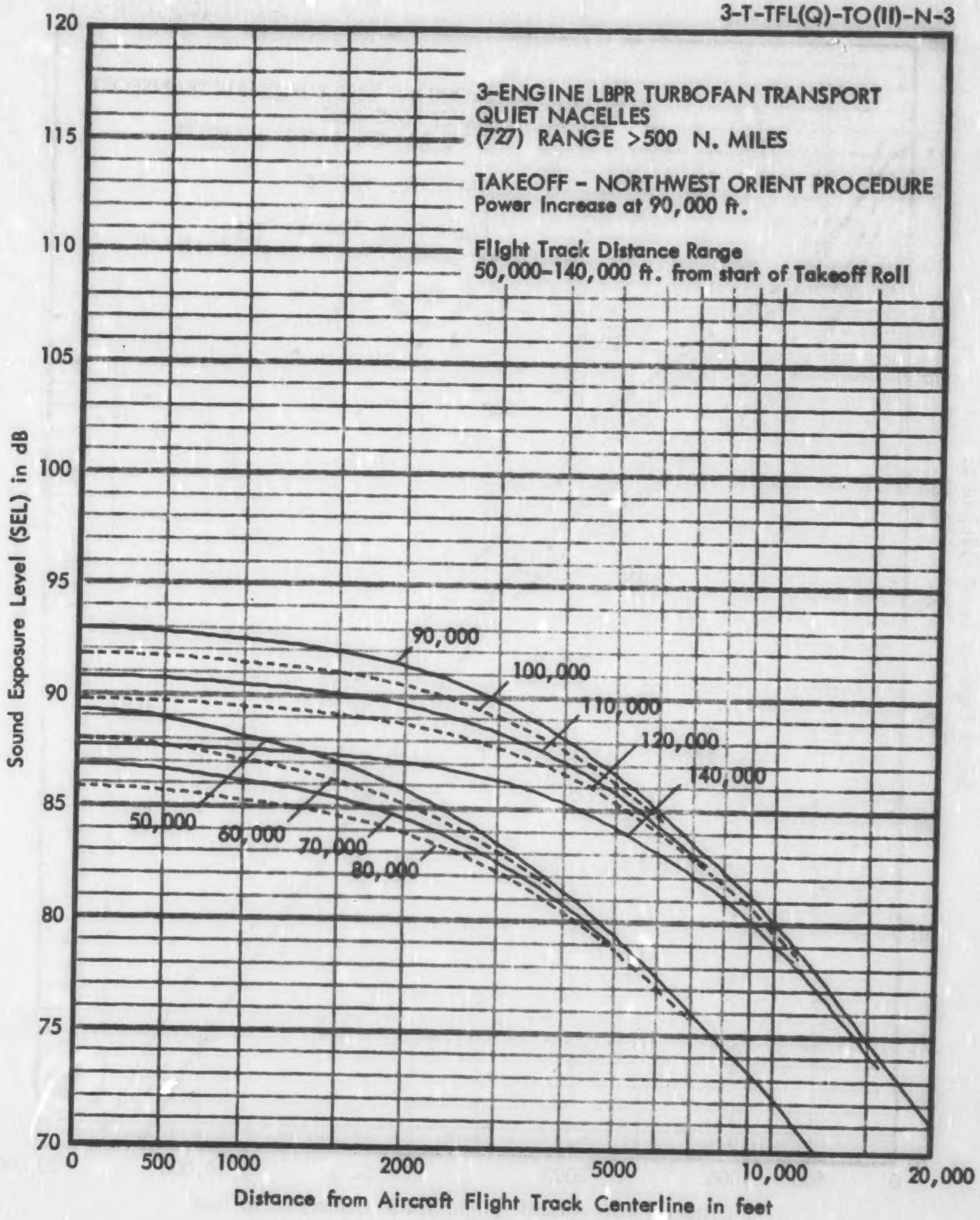

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 14,000 ft.
Flight Track Distance Range
8,000-50,000 ft. from start of Takeoff Roll
8000
10,000
14,000
16,000
18,000
20,000
30,000
40,000
50,000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

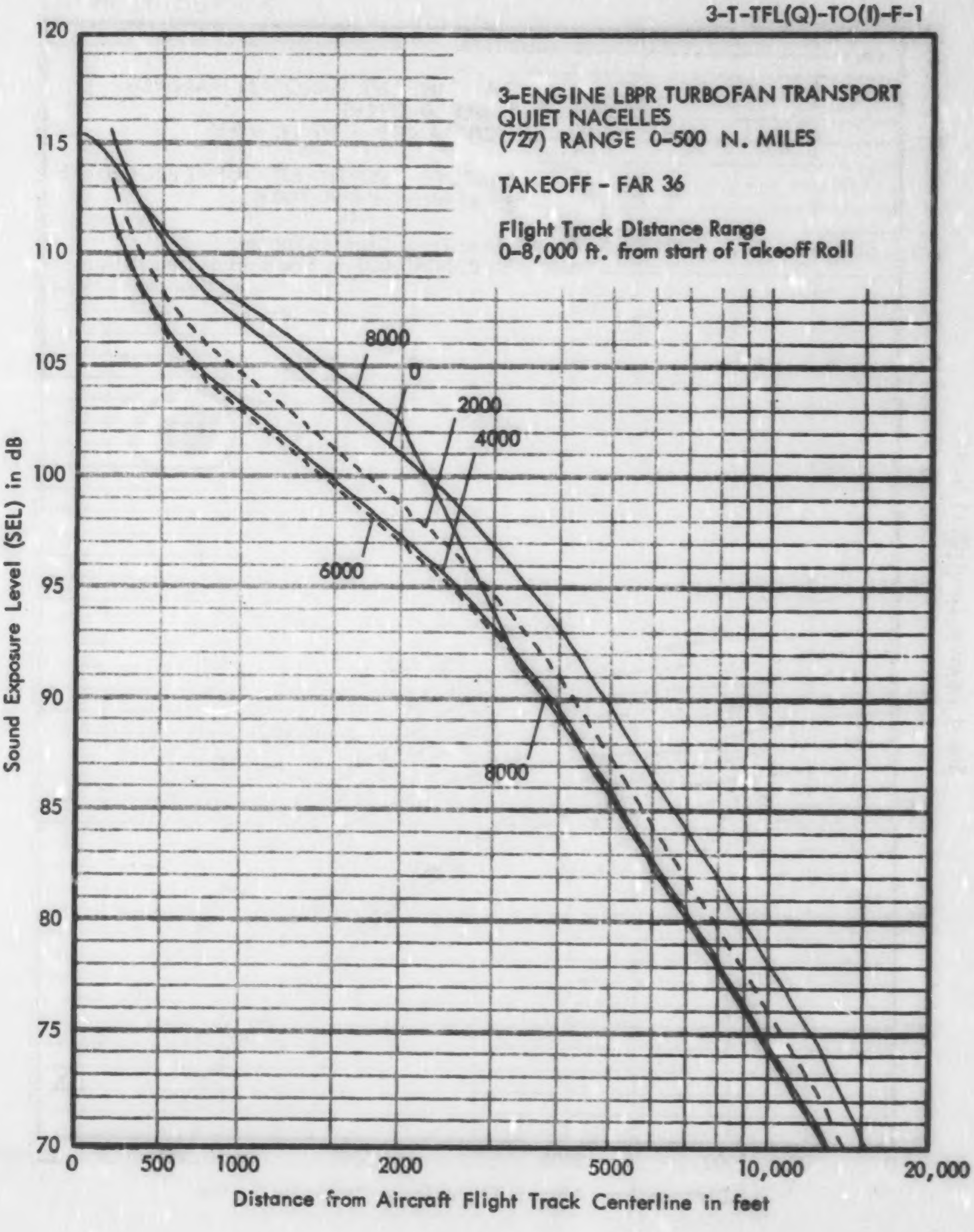
3-T-TFL(Q)-TO(I)-N-3



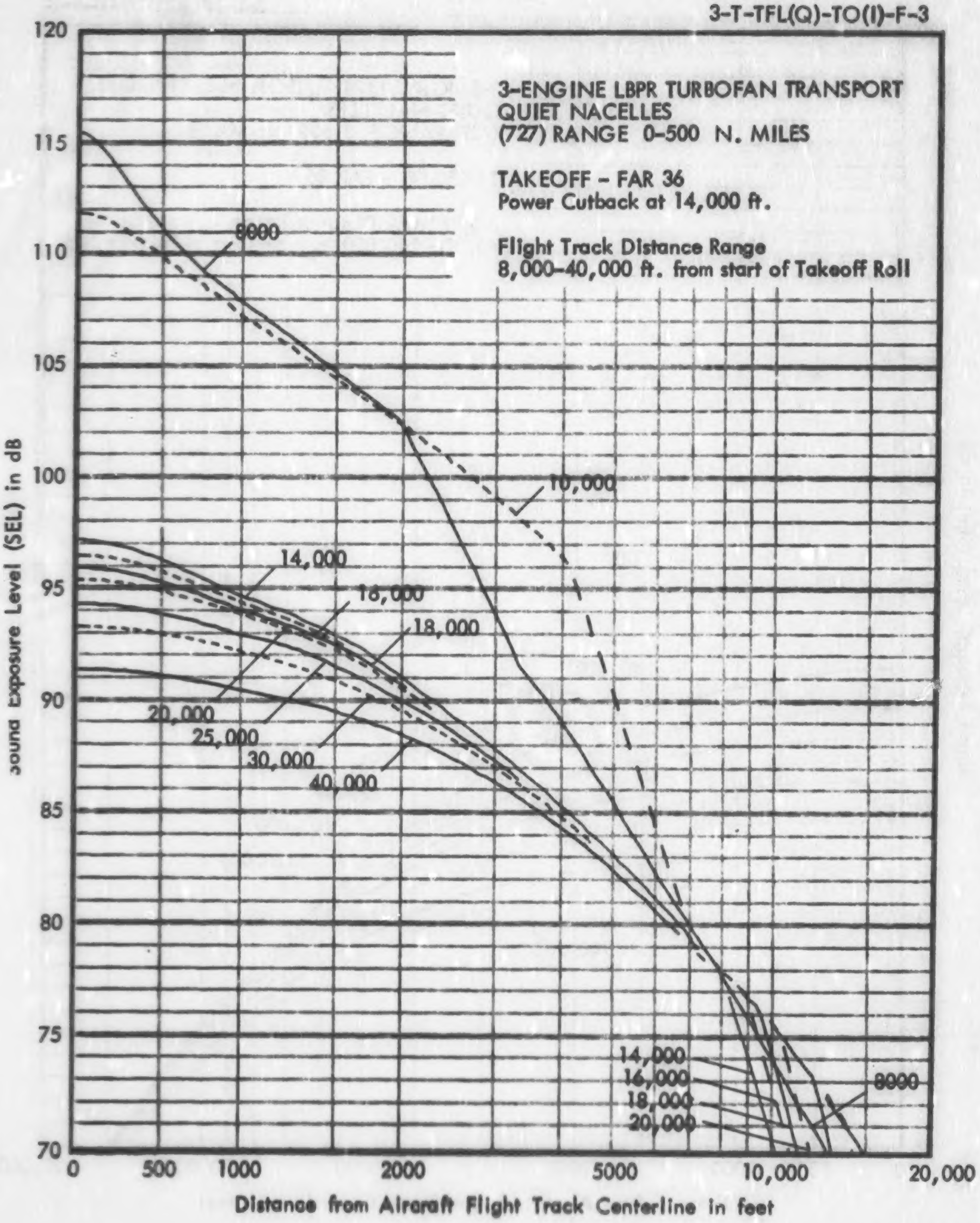

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE >500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
10,000
0
2000
4000
6000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

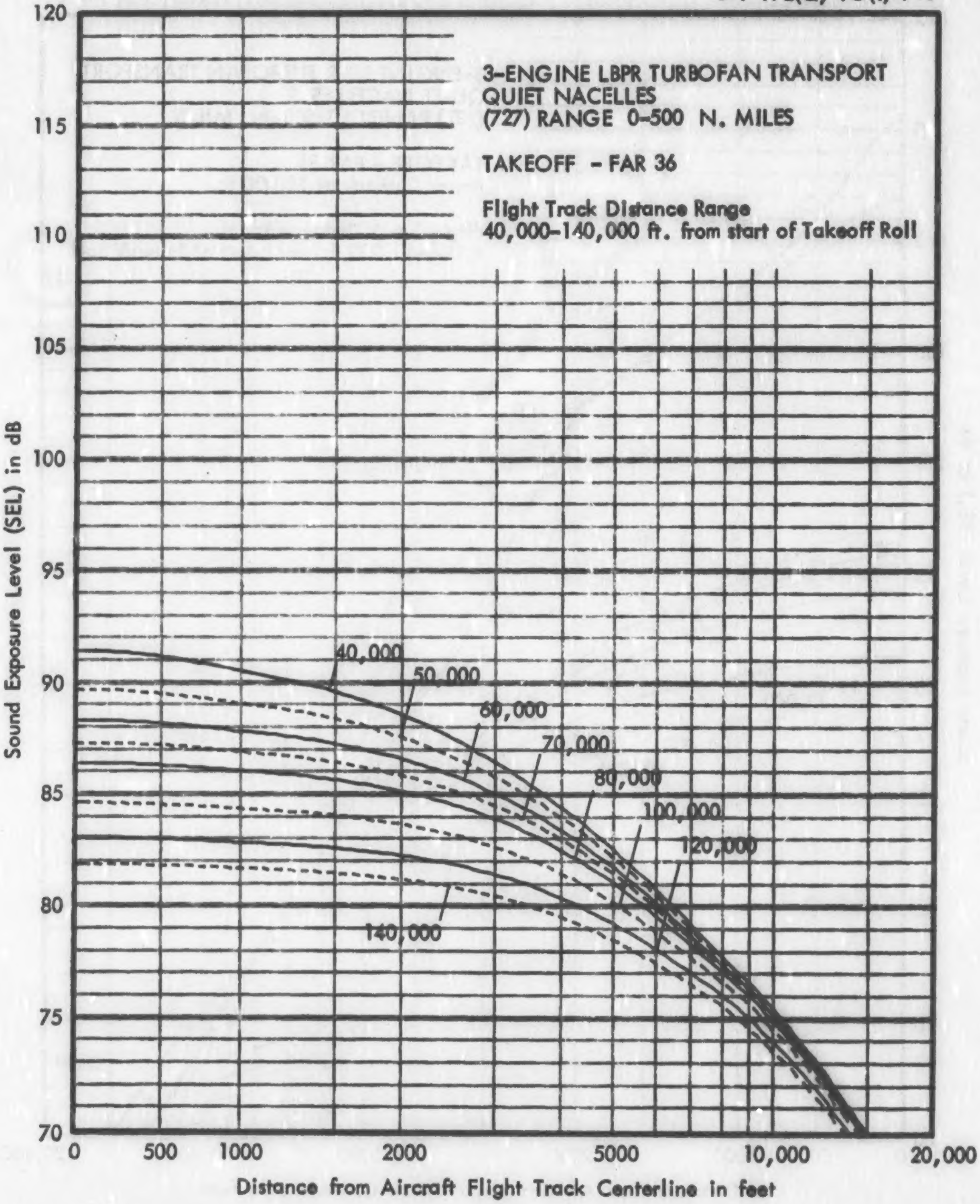

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE >500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 14,000 ft.
Flight Track Distance Range
10,000-50,000 ft. from start of Takeoff Roll
10,000
12,000
14,000
20,000
30,000
40,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

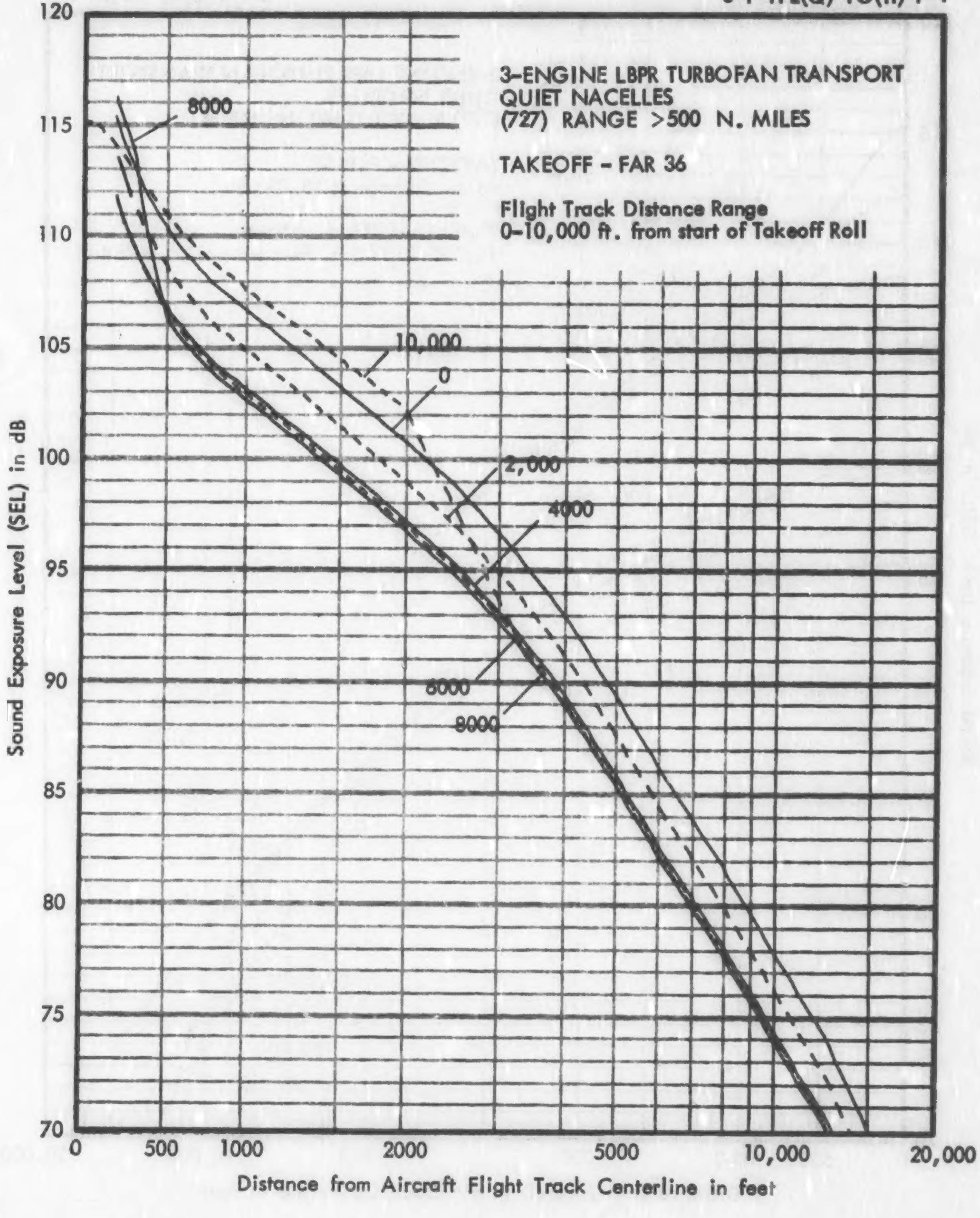

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE >500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 90,000 ft.
Flight Track Distance Range
50,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
90,000
100,000
110,000
120,000
140,000
50,000
60,000
70,000
80,000


3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

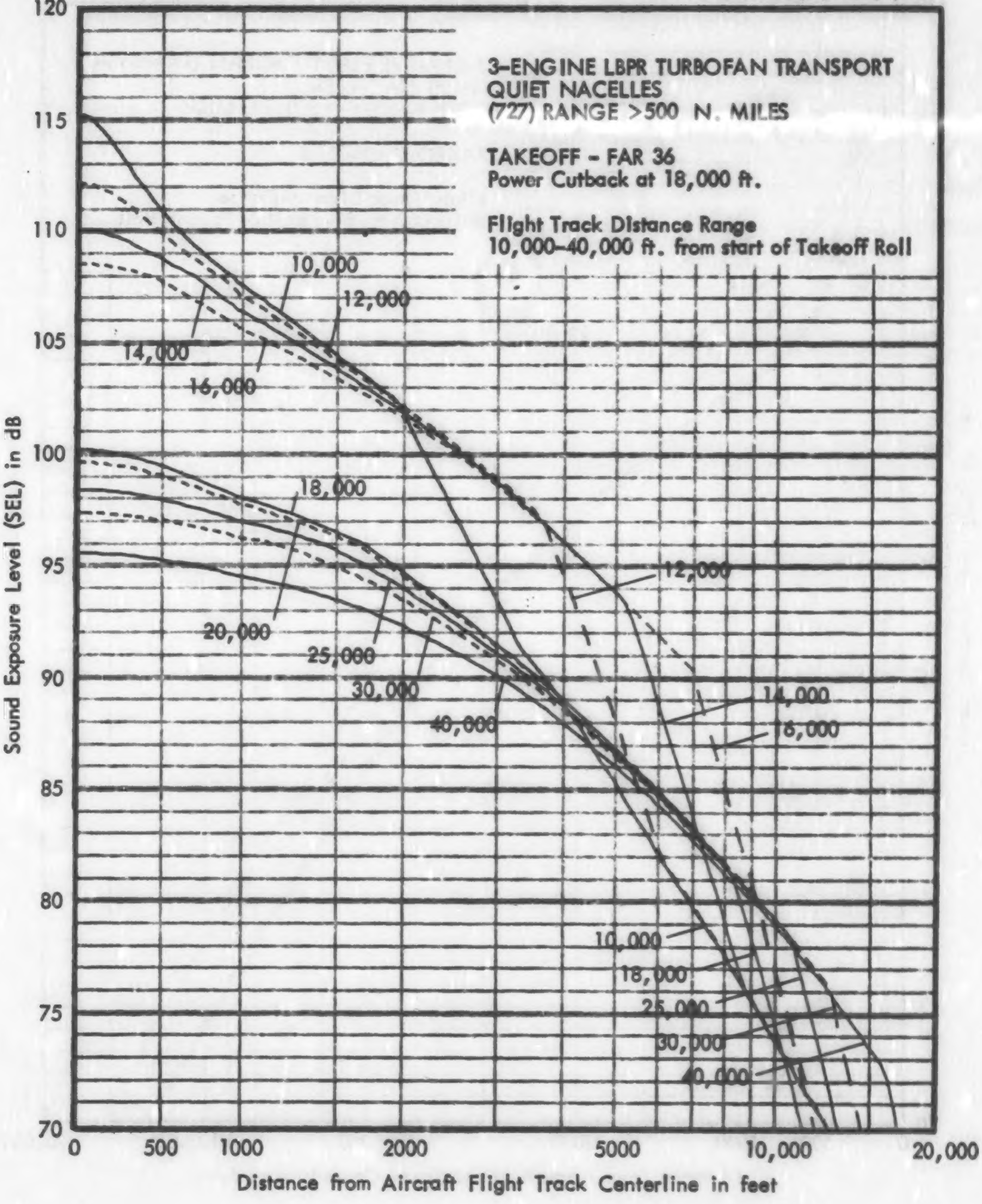
3-T-TFL(Q)-TO(I)-F-3

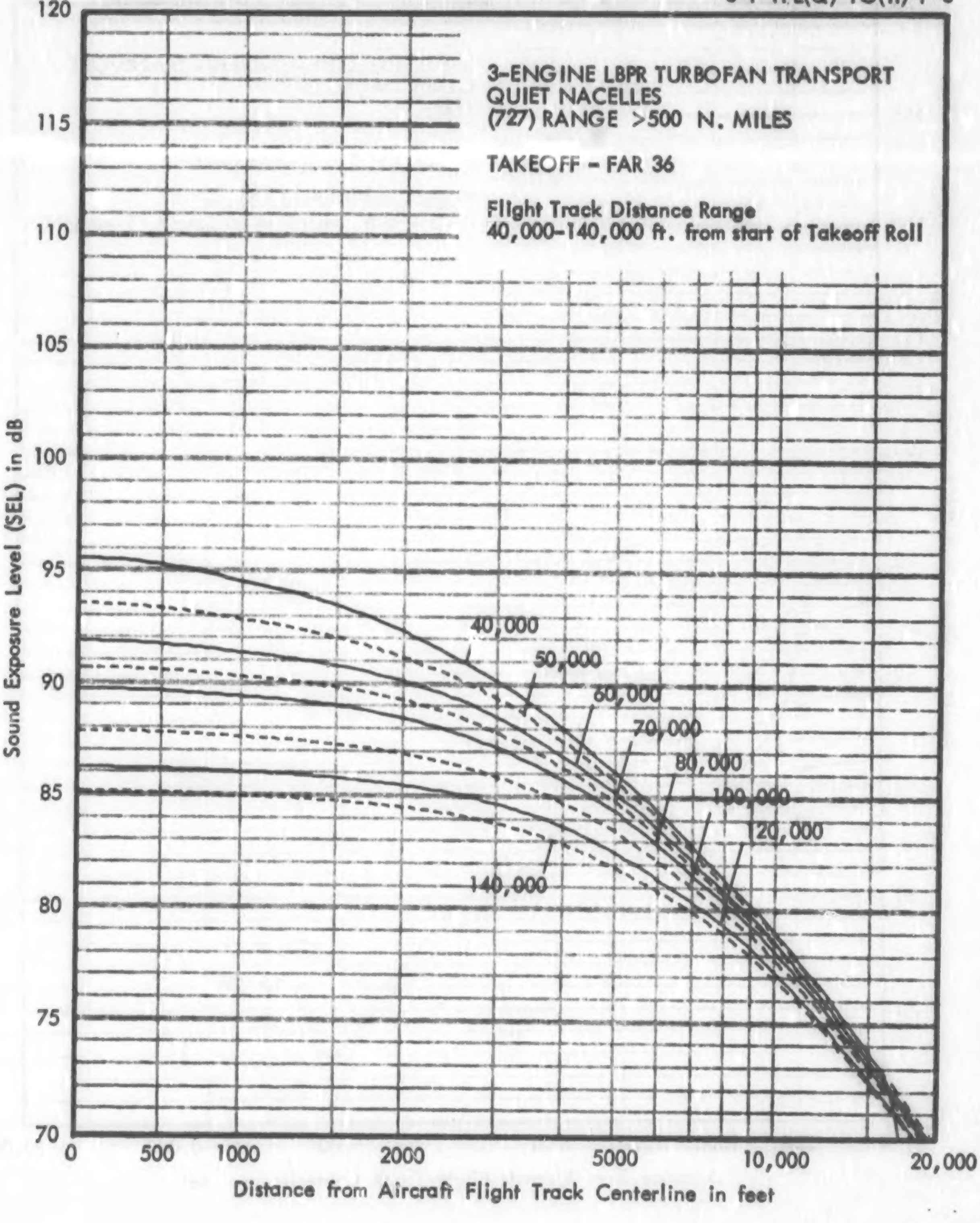


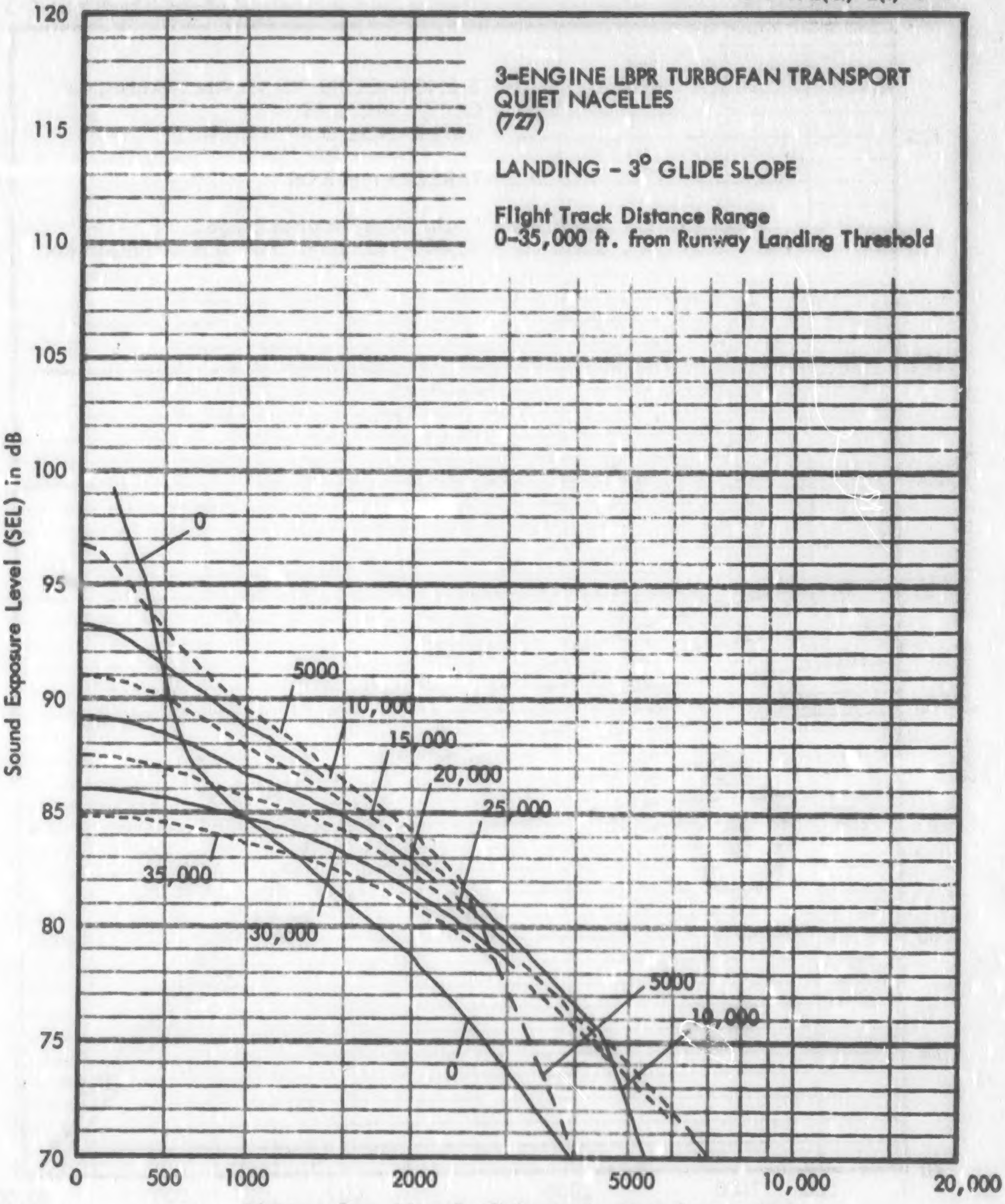

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
40,000
50,000
60,000
70,000
80,000
100,000
120,000
140,000

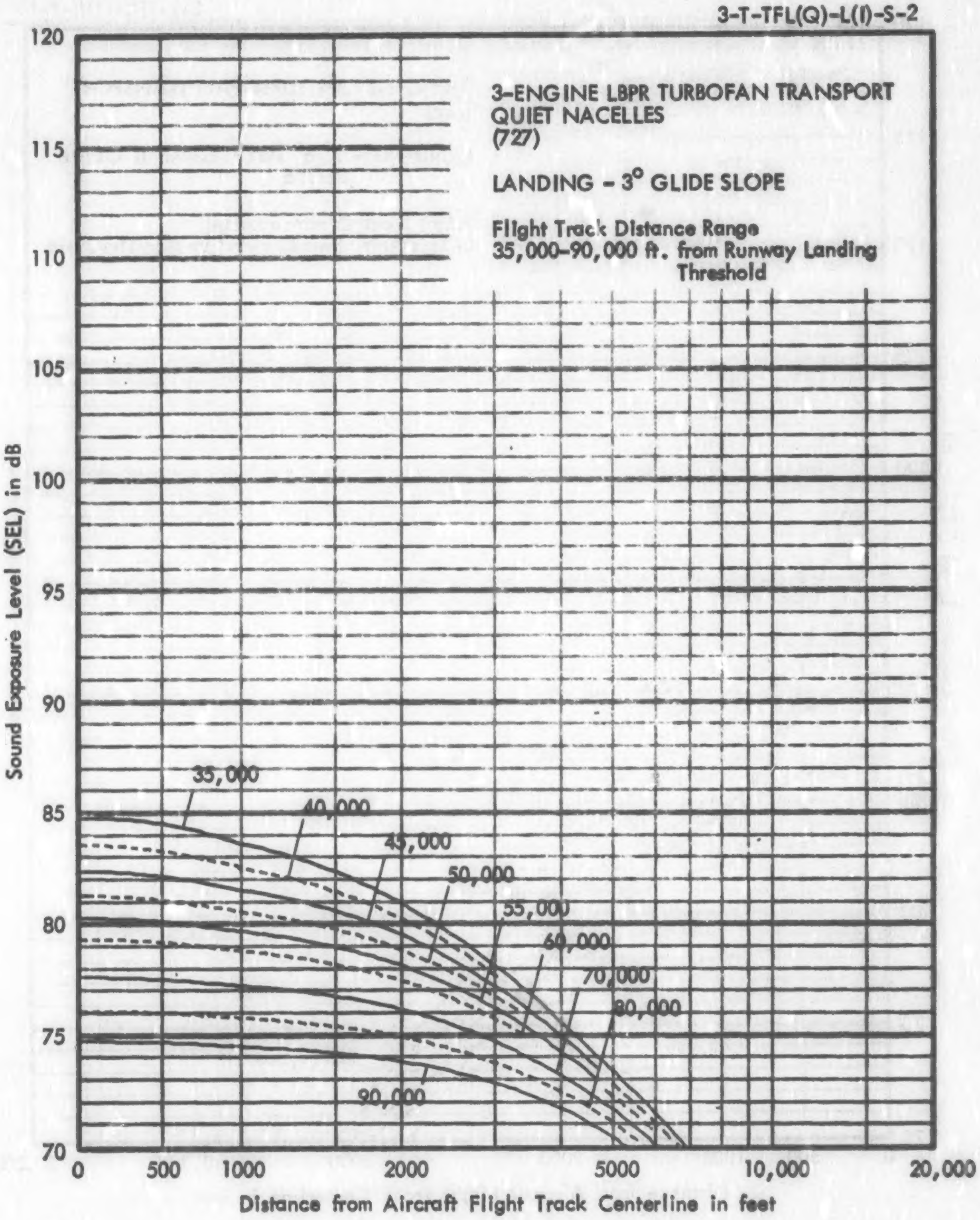

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE >500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
8000
10,000
0
2,000
4000
6000
8000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

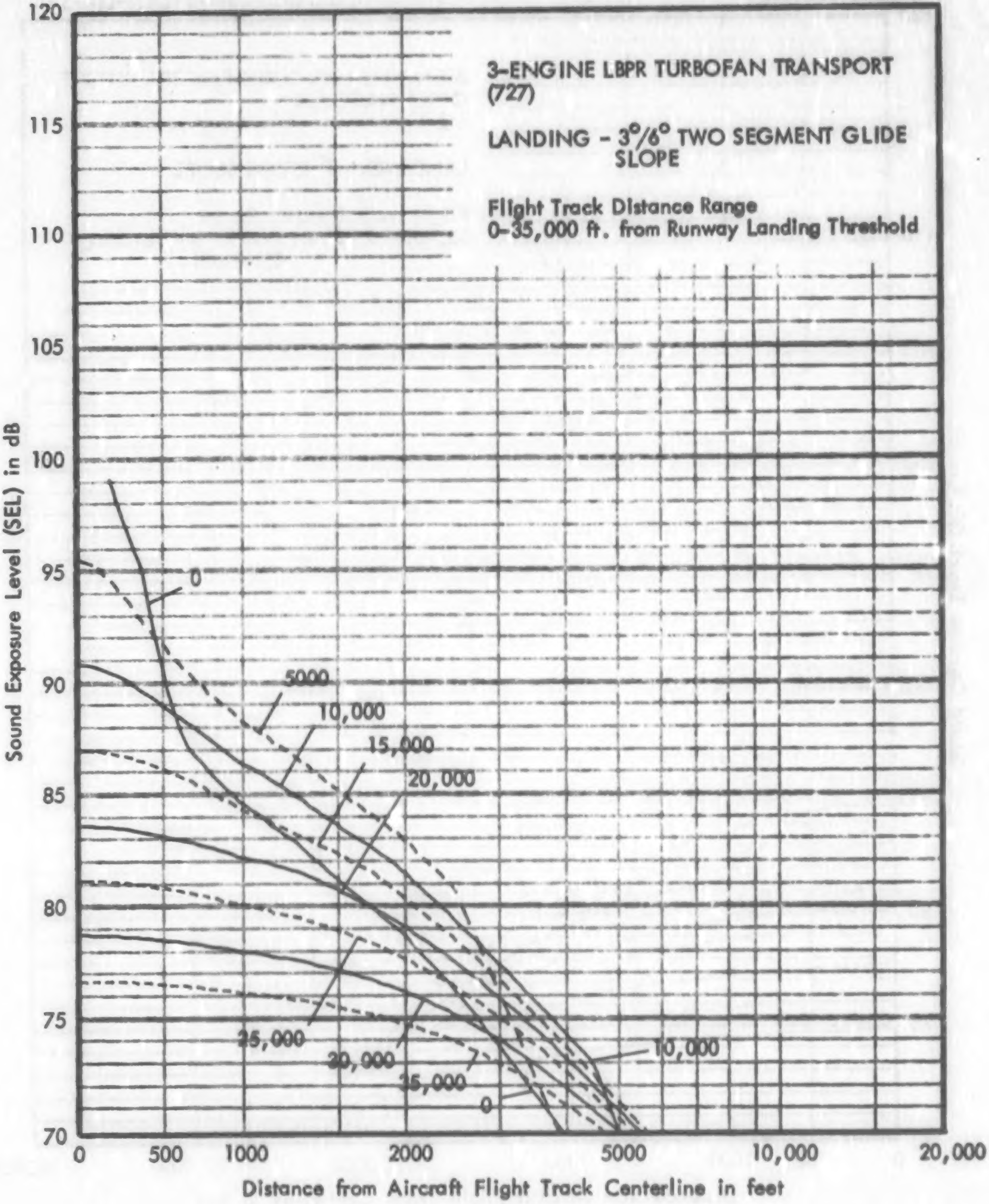
3-T-TFL(Q)-TO(II)-F-2

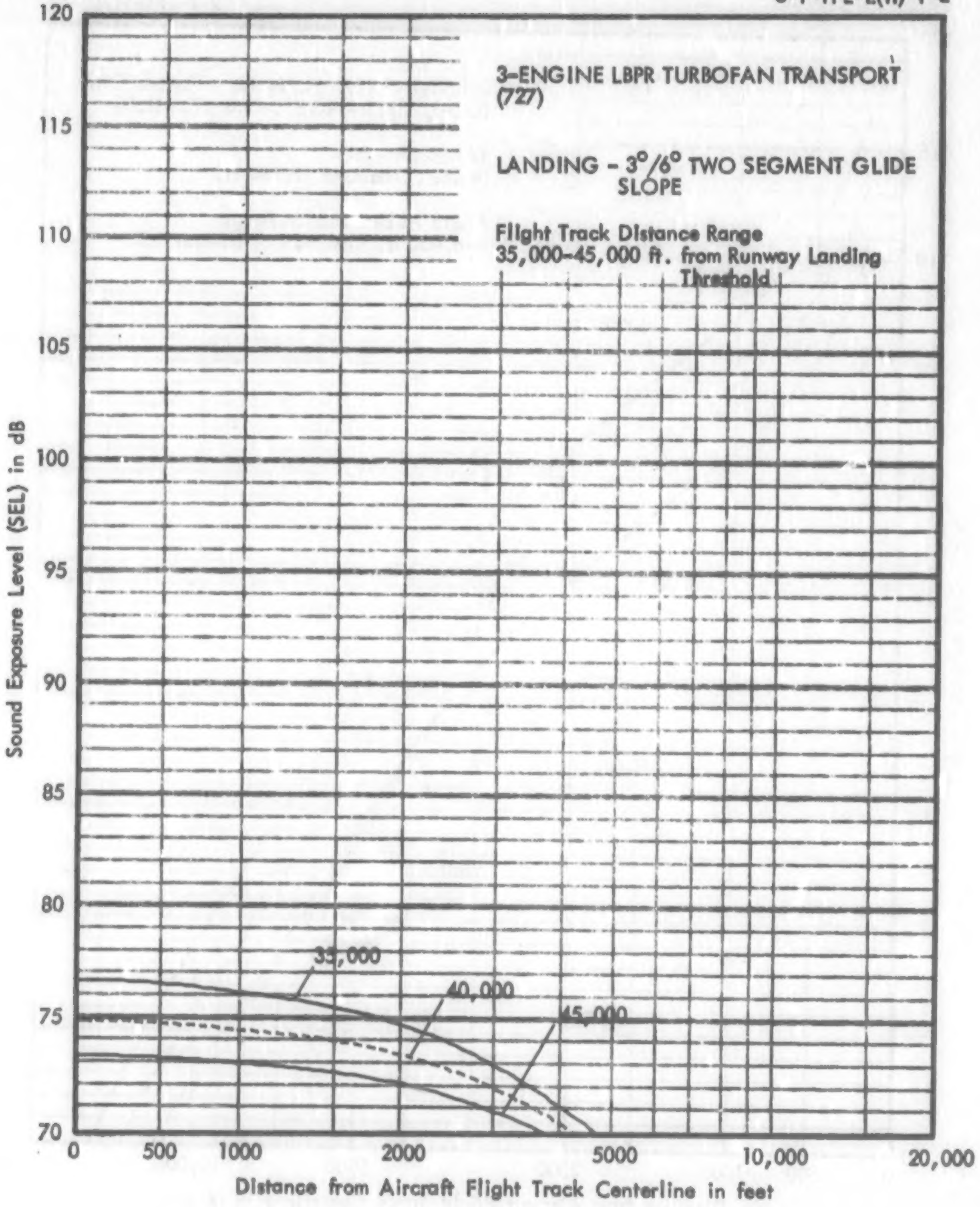



3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727) RANGE >500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll
40,000
50,000
60,000
70,000
80,000
100,000
120,000
140,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

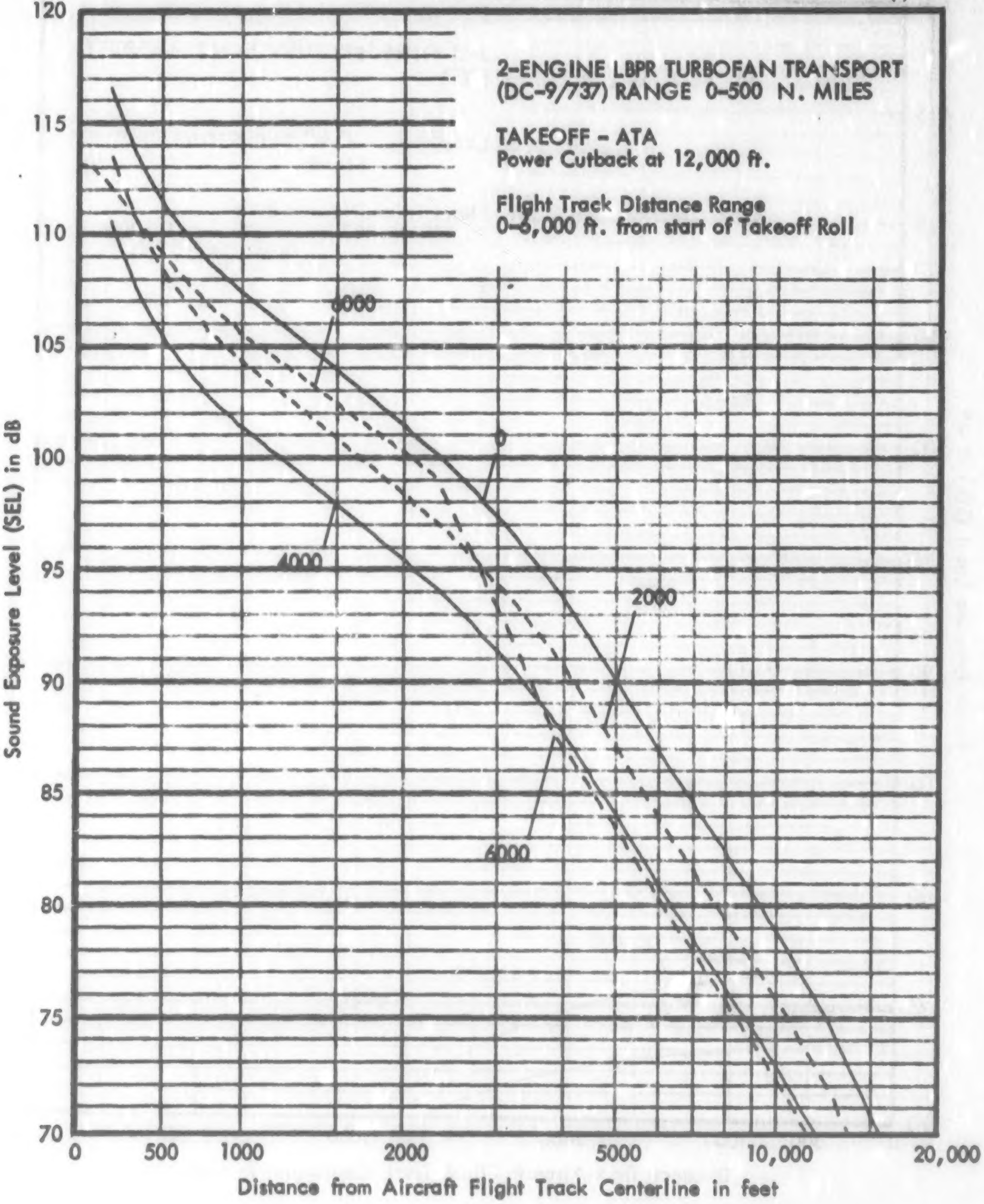

3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5000
10,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


3-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(727)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
35,000-90,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
50,000
55,000
60,000
70,000
80,000
90,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

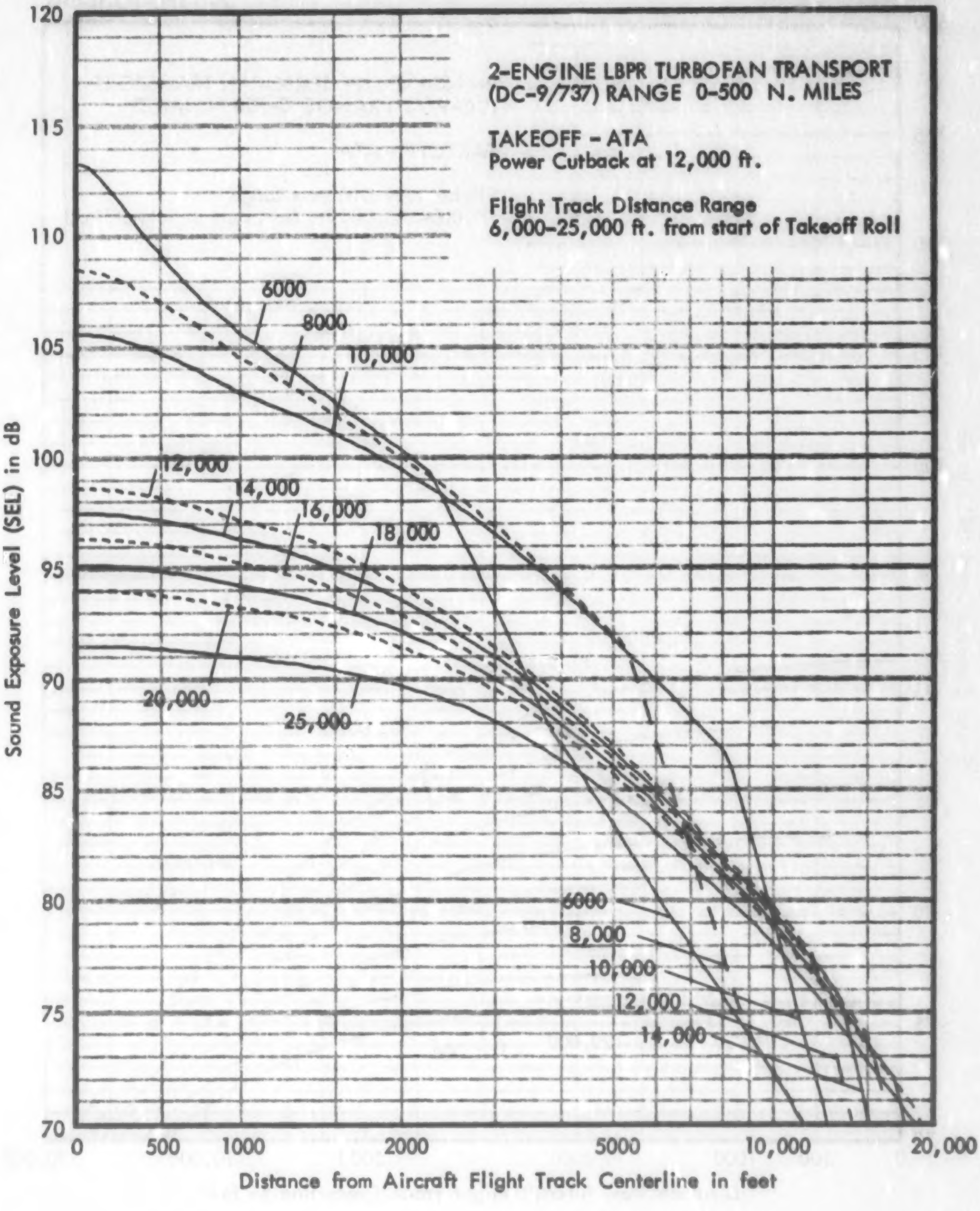

3-ENGINE LBPR TURBOFAN TRANSPORT (727)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range 0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
5000
10,000
15,000
20,000
25,000
20,000
35,000
0
10,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

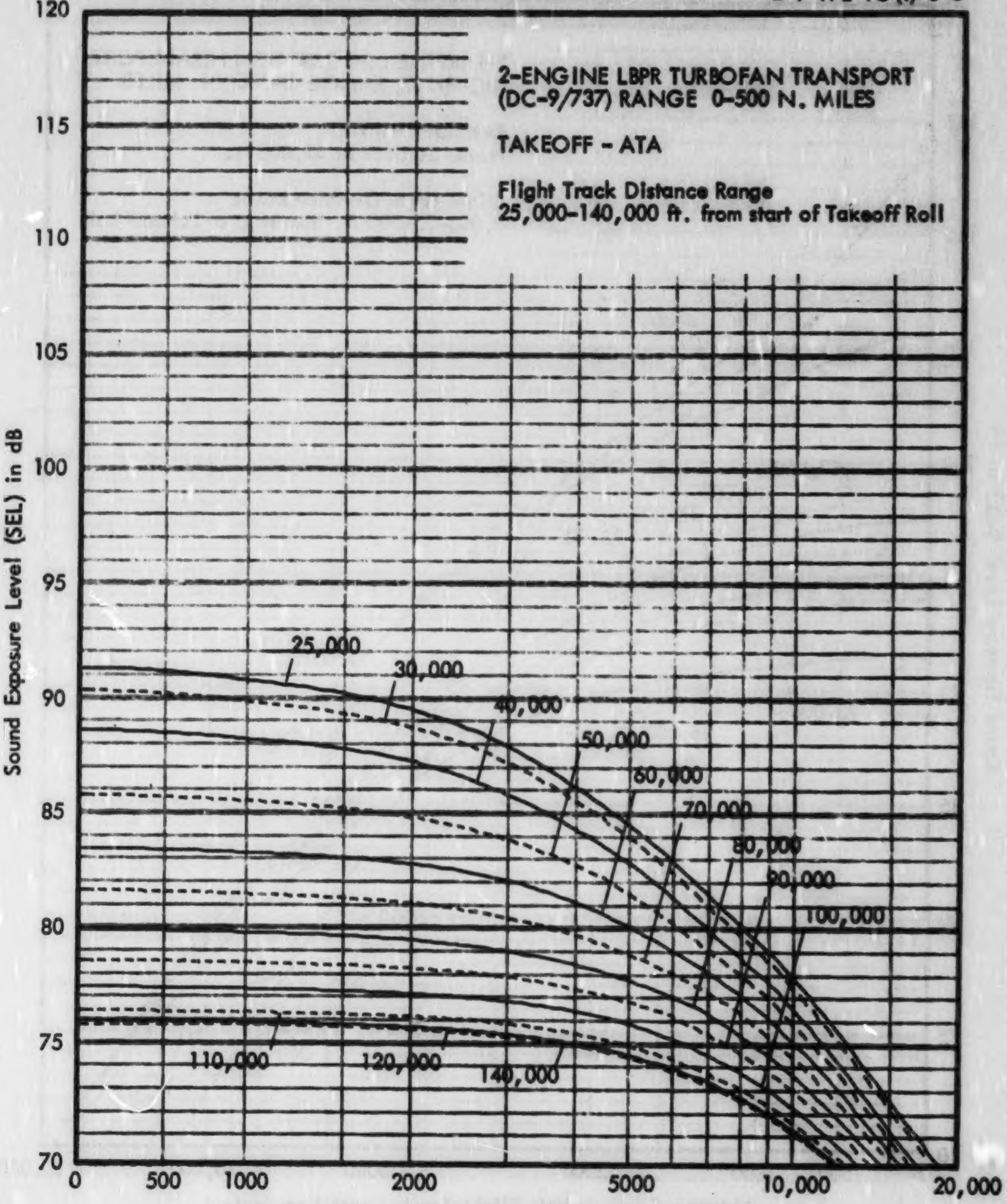

3-ENGINE LBPR TURBOFAN TRANSPORT (727)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range 35,000-45,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

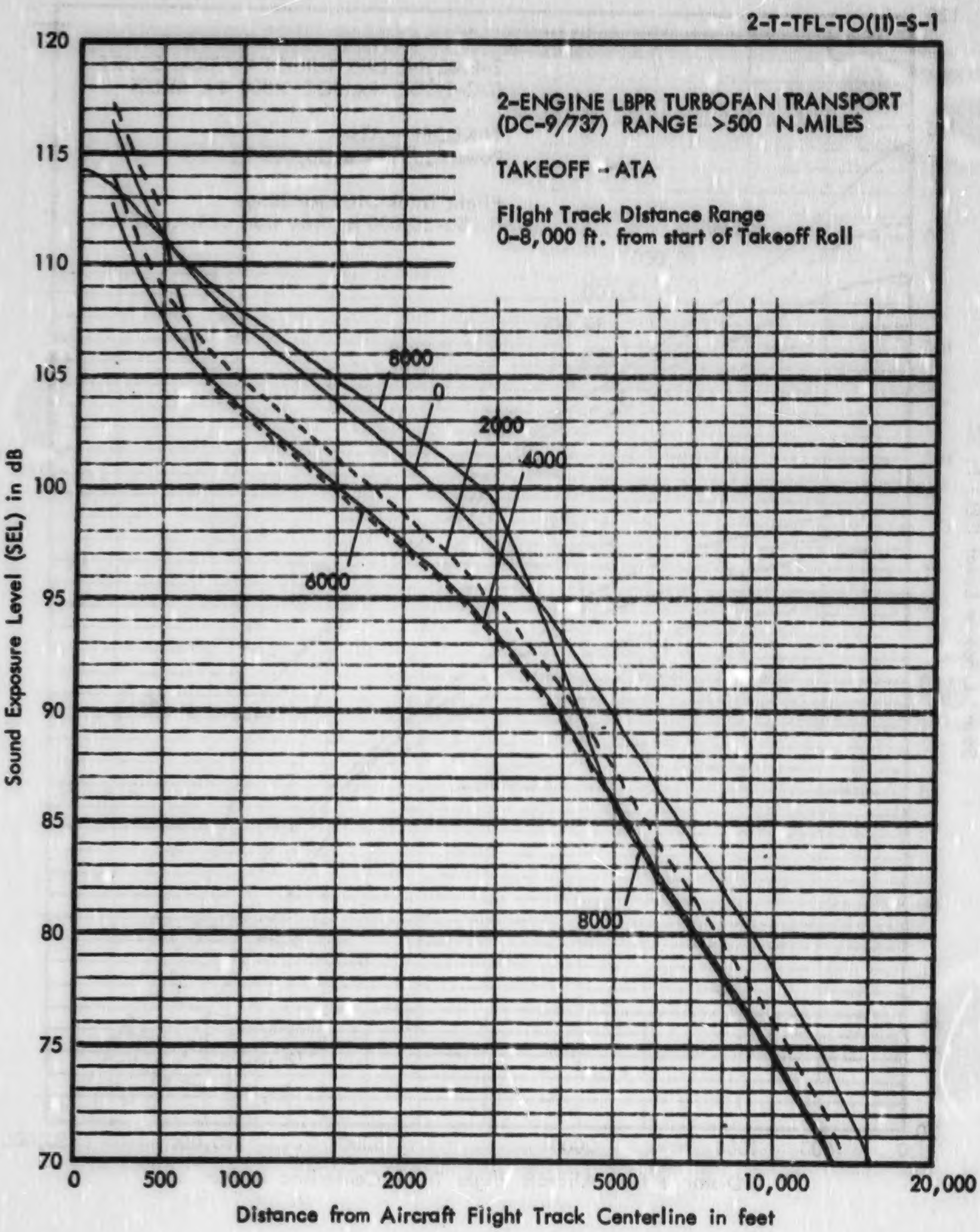
2-T-TFL-TO(I)-S-1


2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - ATA
Power Cutback at 12,000 ft.
Flight Track Distance Range
0-6,000 ft. from start of Takeoff Roll
3000
0
4000
2000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

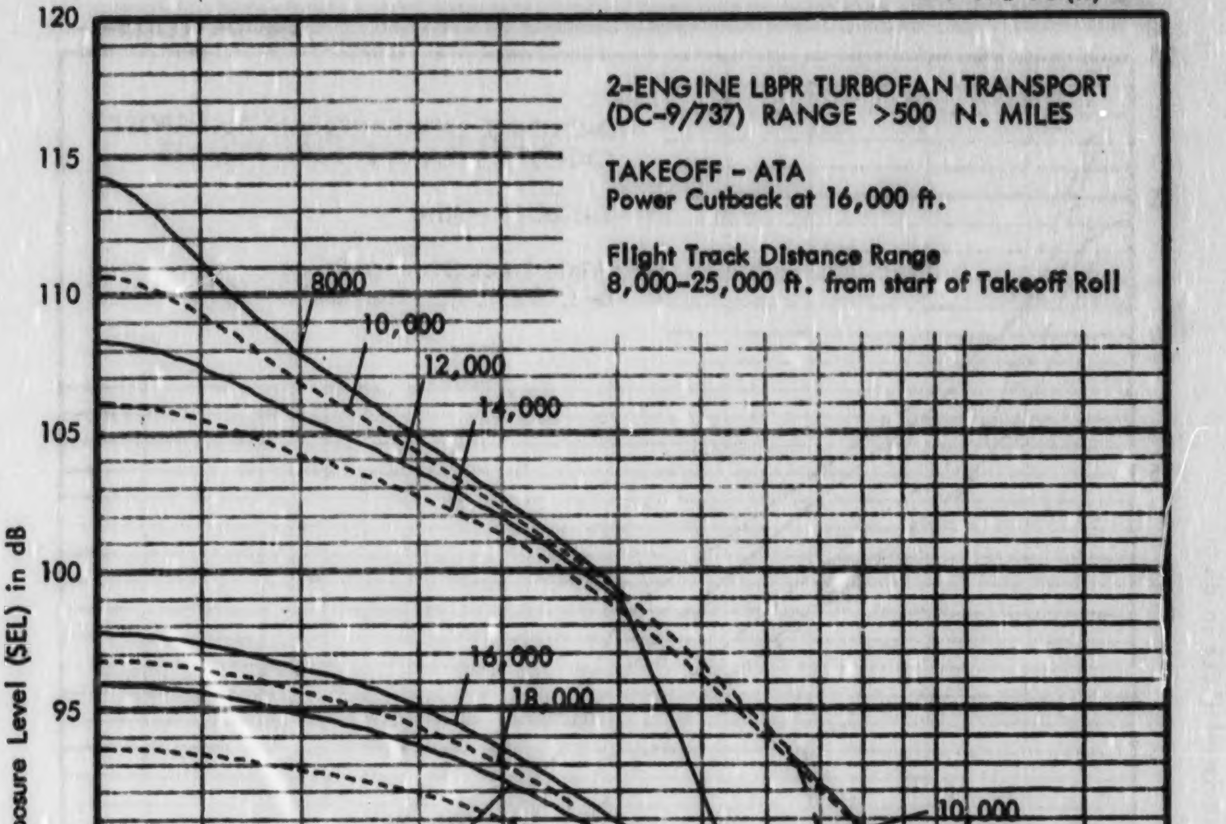
2-T-TFL-TO(I)-S-2


2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - ATA
Power Cutback at 12,000 ft.
Flight Track Distance Range
6,000-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
6000
8,000
10,000
12,000
14,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

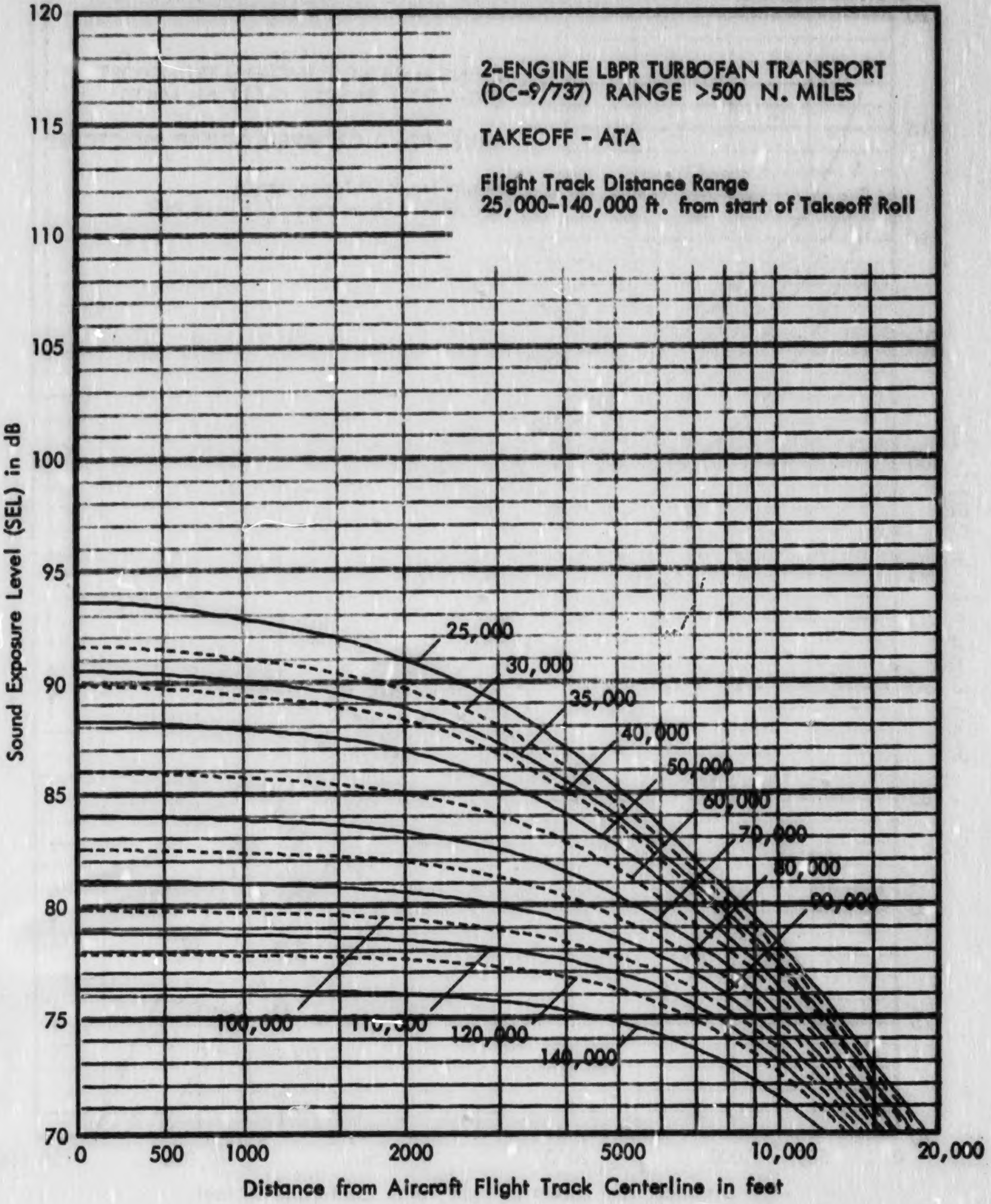

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
25,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
25,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
140,000


2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE >500 N.MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

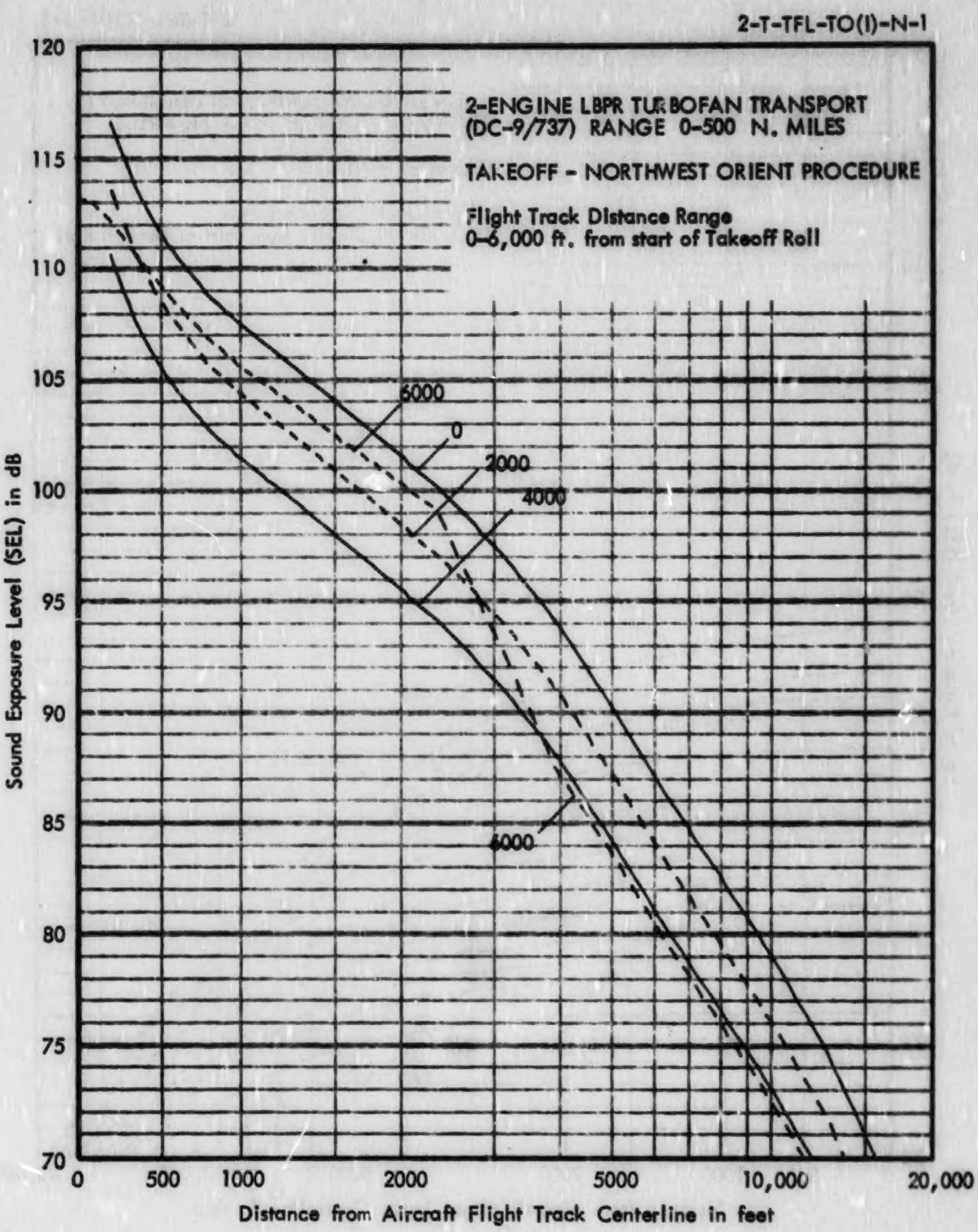
2-T-TFL-TO(II)-S-2



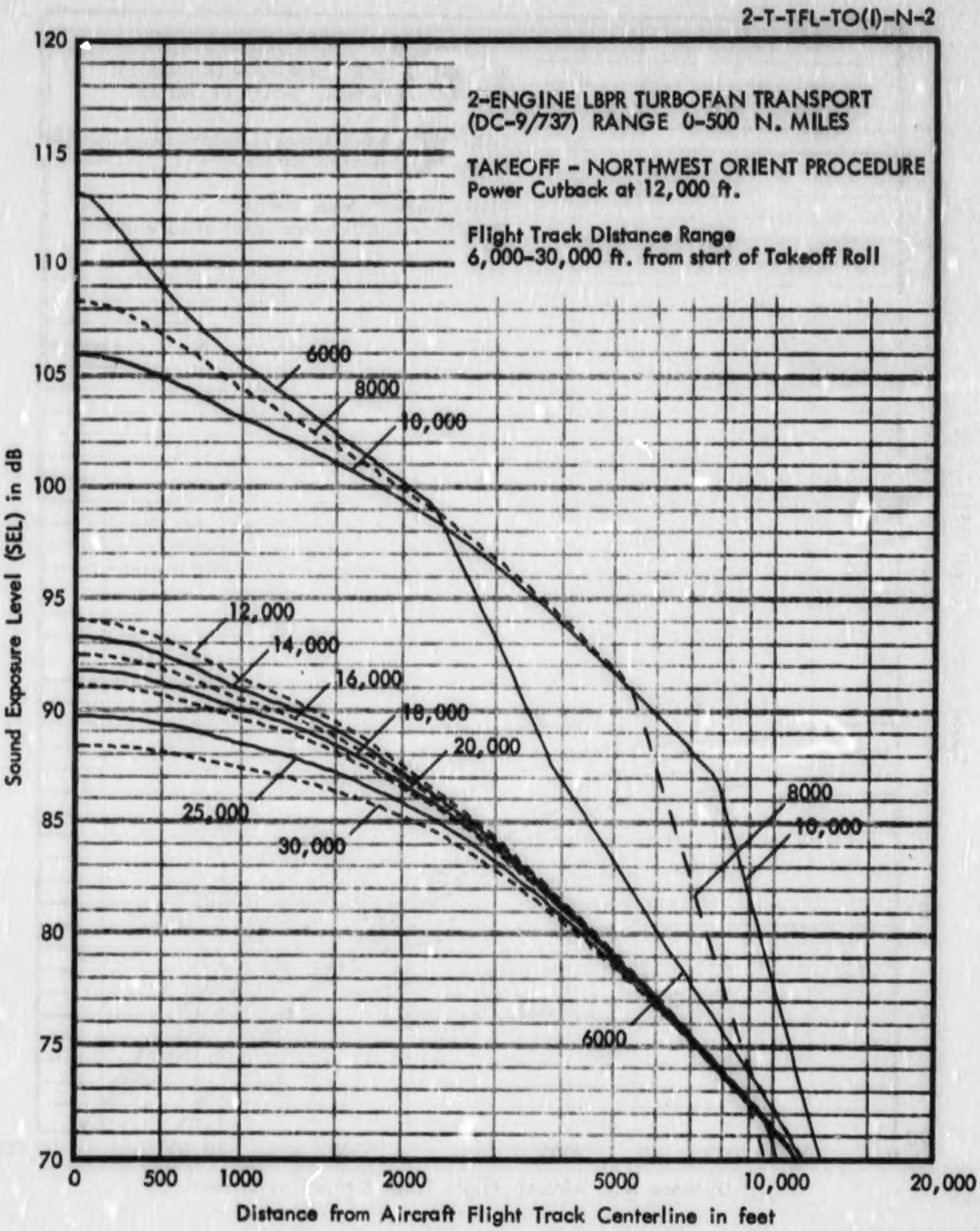
2-T-TFL-TO(II)-S-3



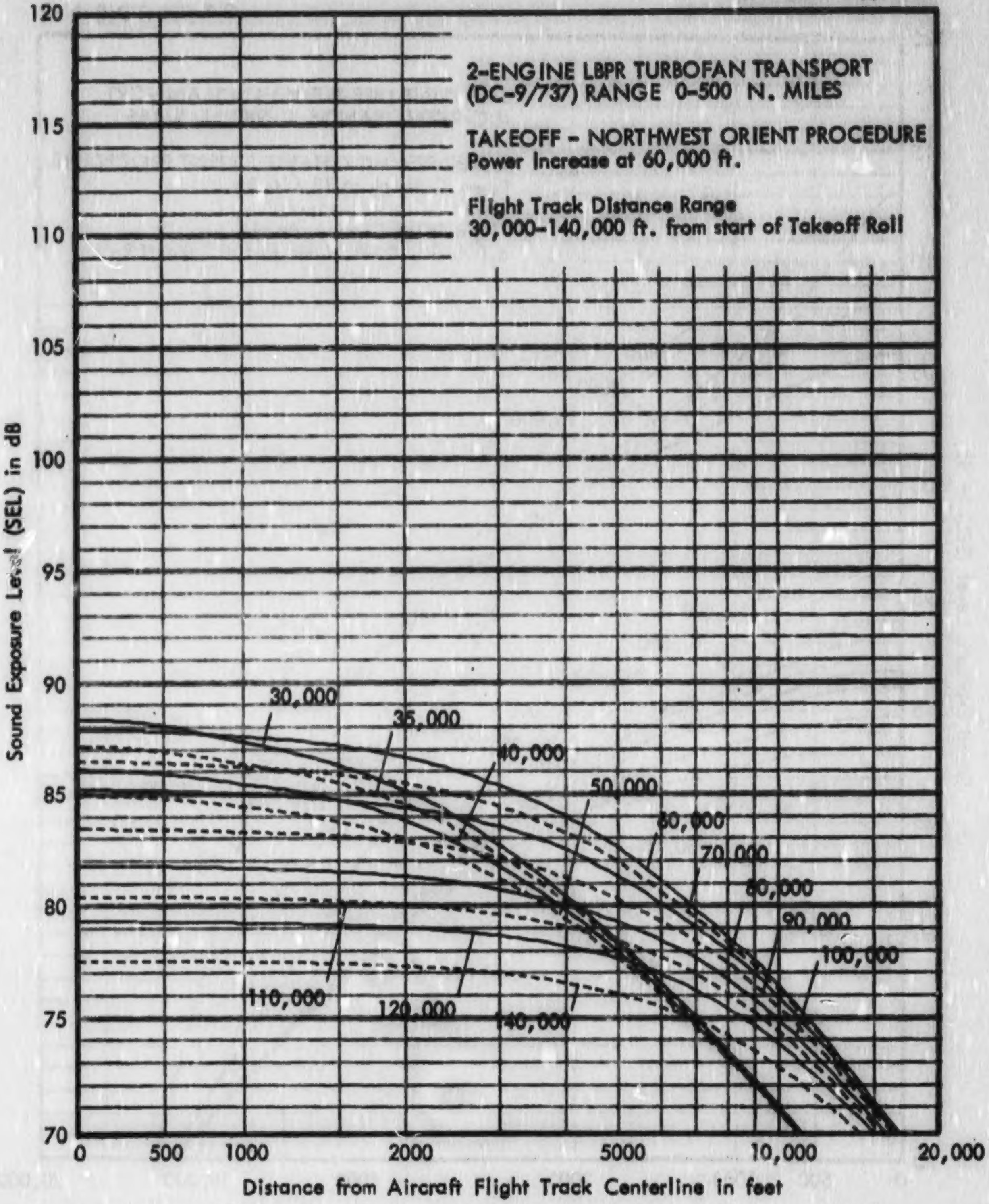
2-T-TFL-TO(I)-N-1

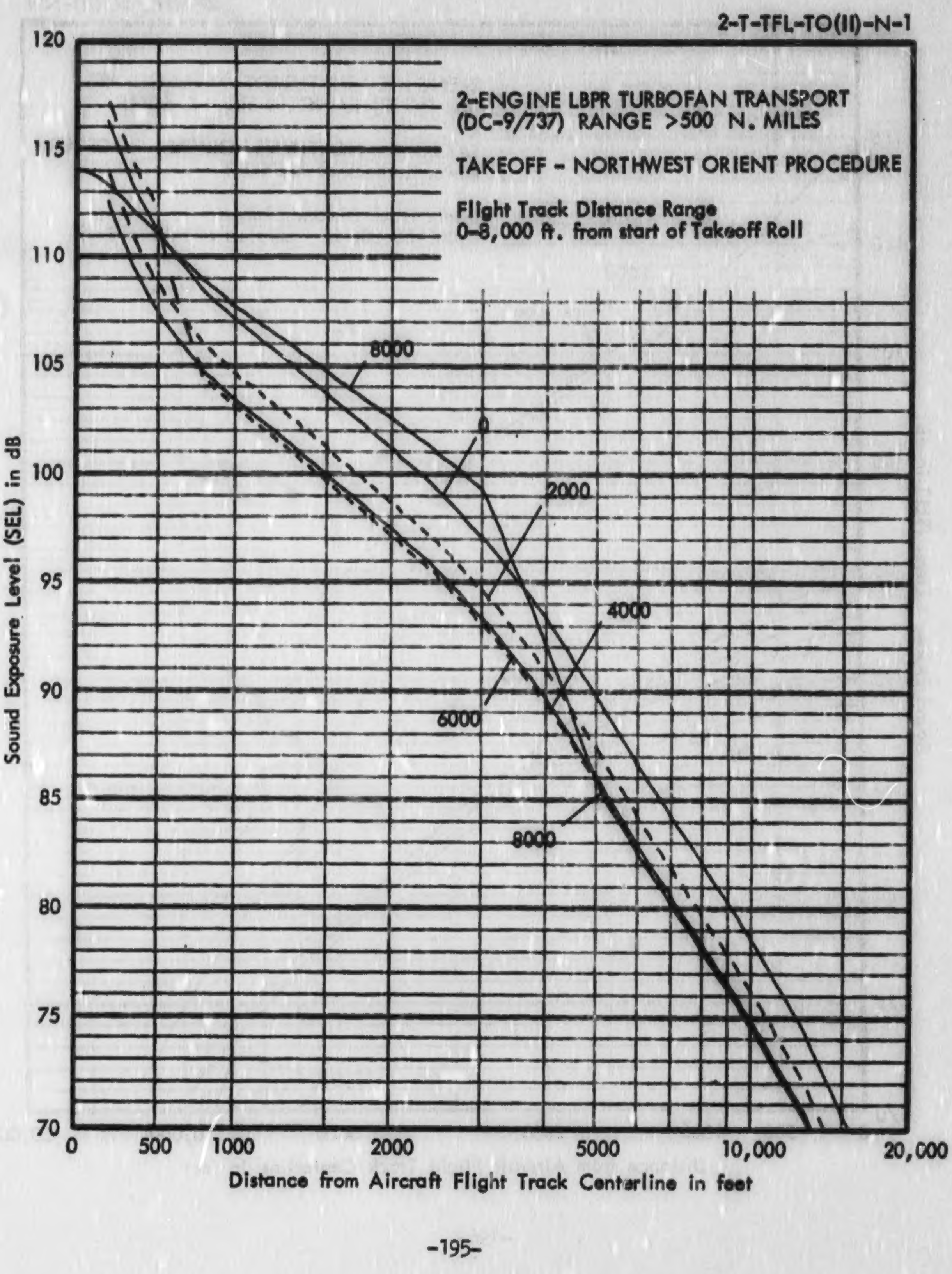

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-6,000 ft. from start of Takeoff Roll
6000
0
2000
4000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

2-T-TFL-TO(I)-N-2

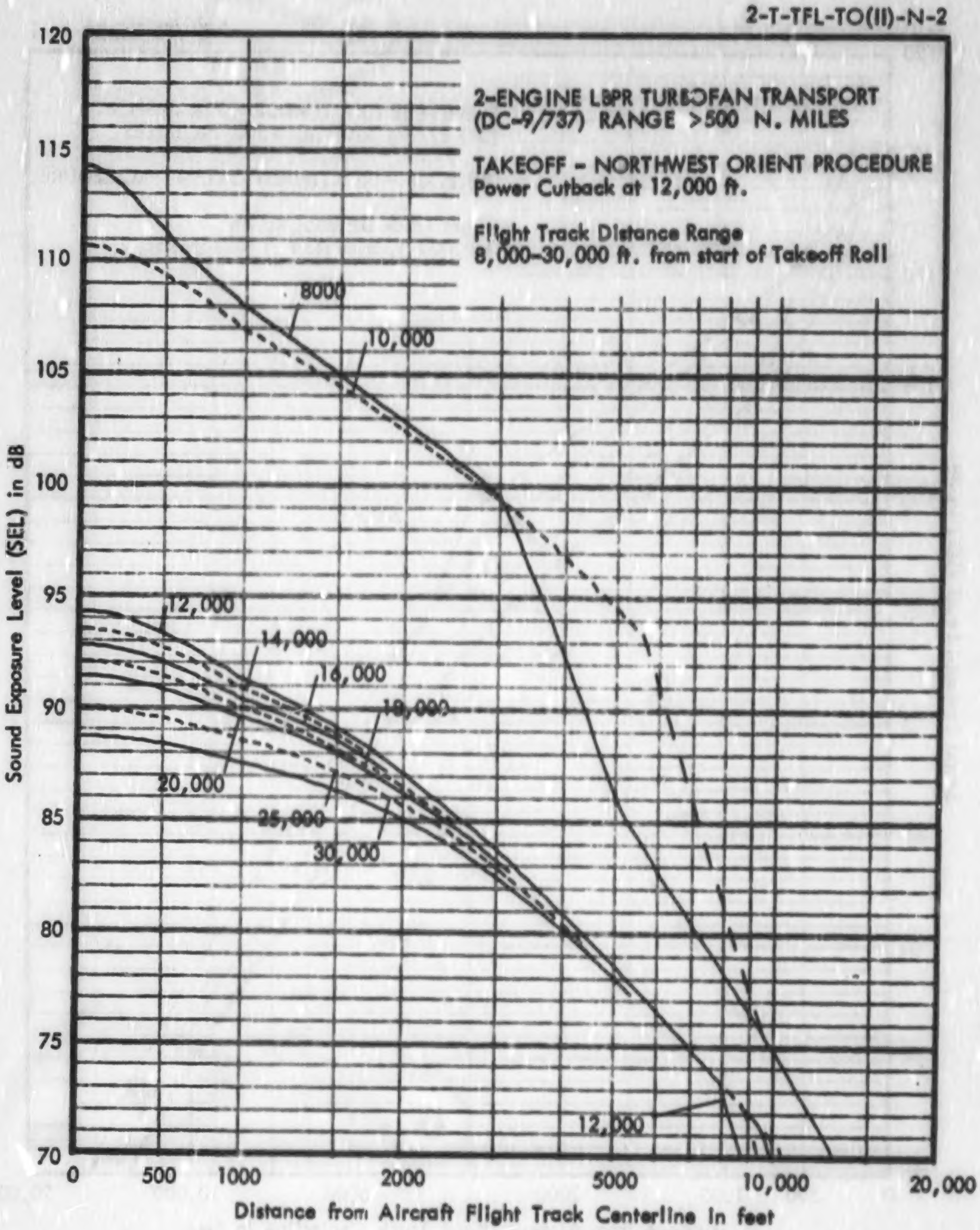

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 12,000 ft.
Flight Track Distance Range
6,000-30,000 ft. from start of Takeoff Roll
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
8000
10,000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

2-T-TFL-TO(I)-N-3

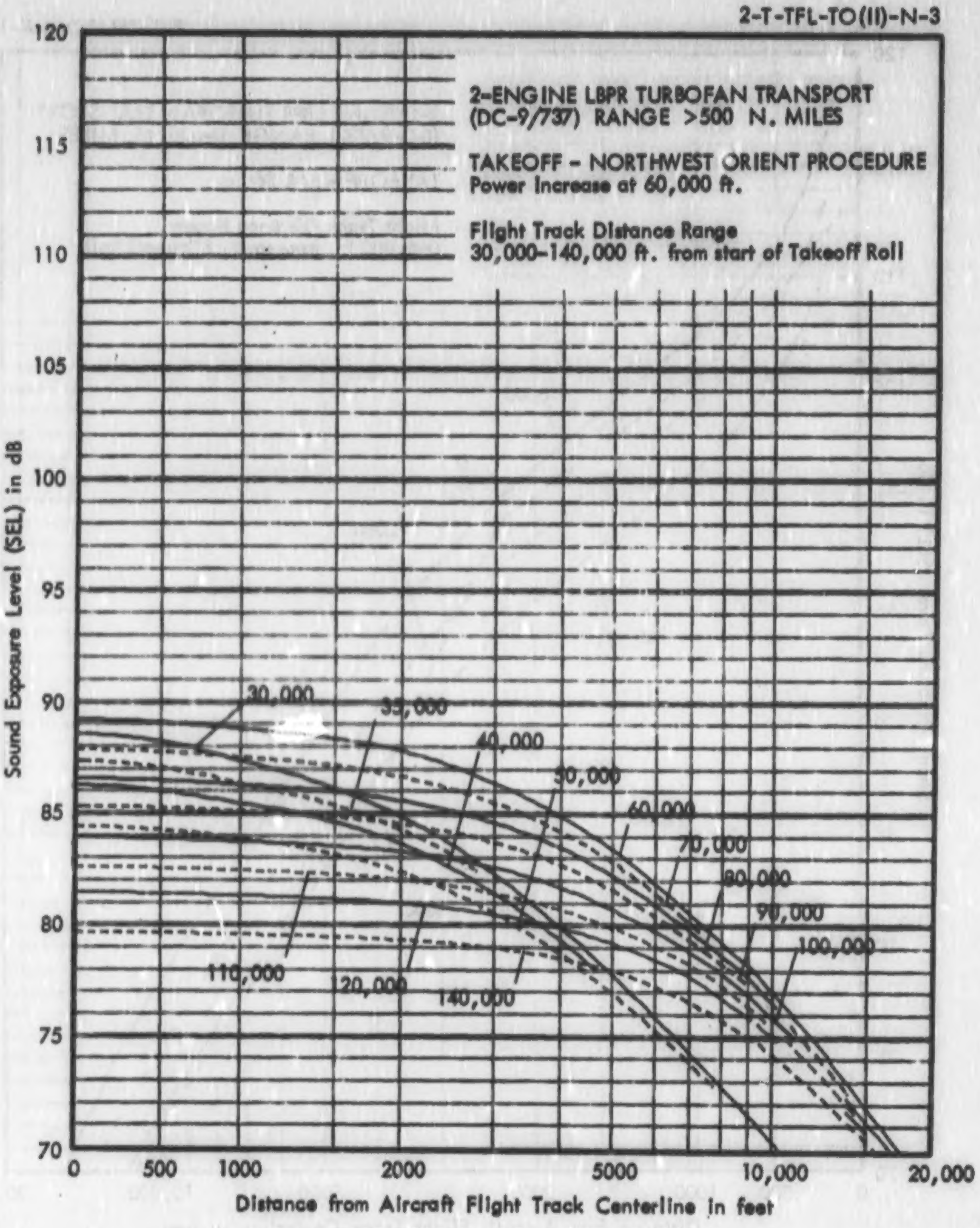

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 60,000 ft.
Flight Track Distance Range
30,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
30,000
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

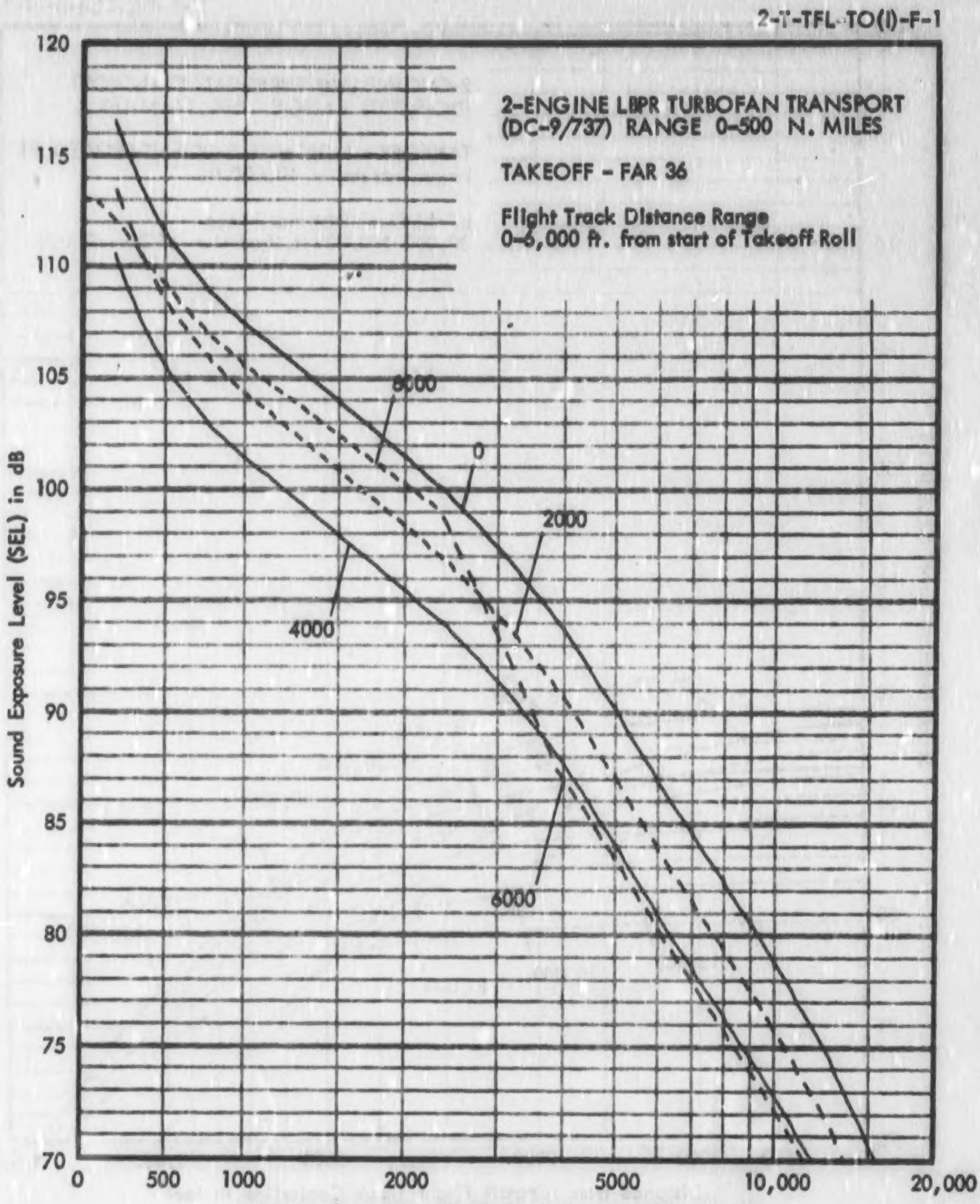

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

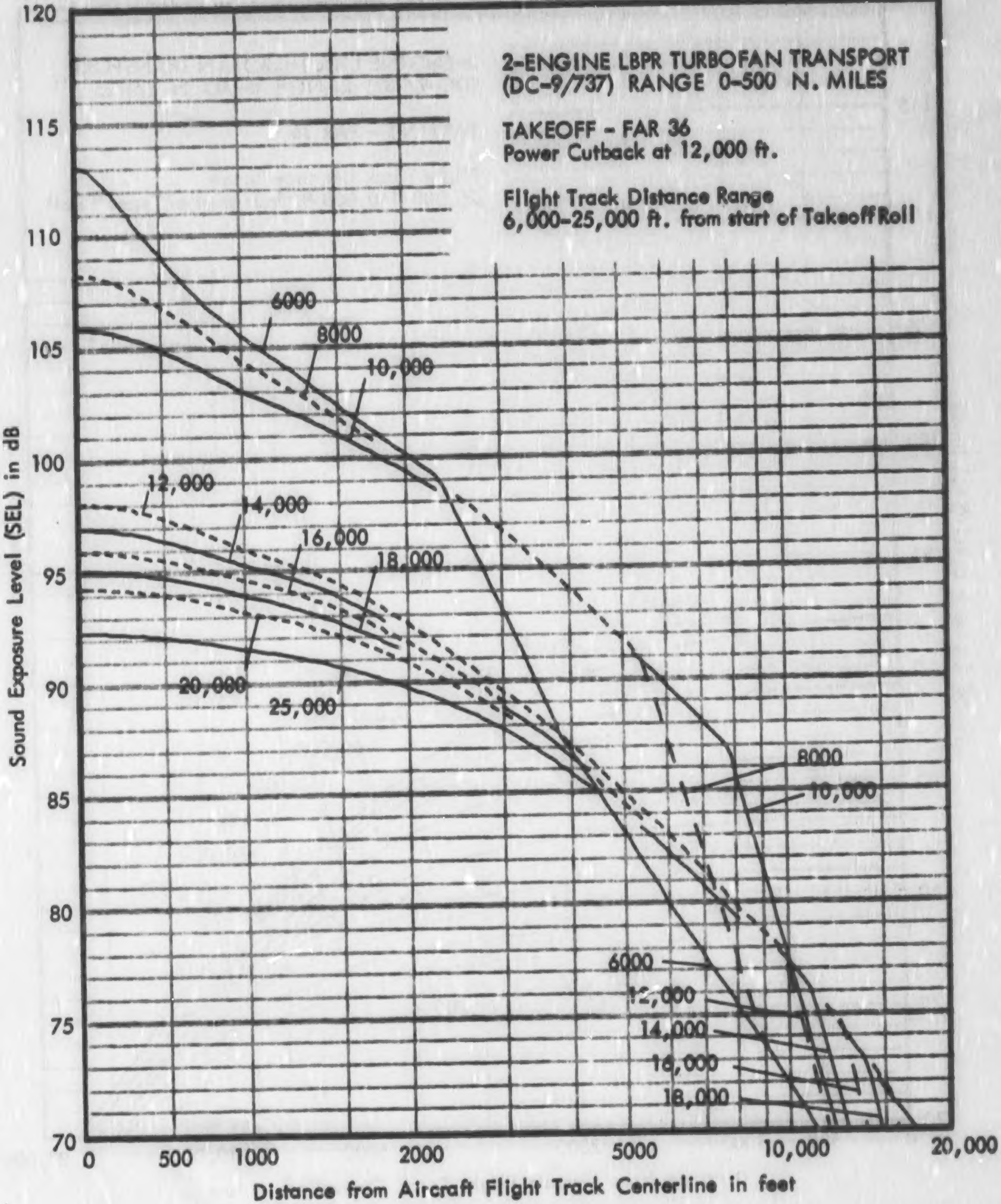
2-T-TFL-TO(II)-N-2

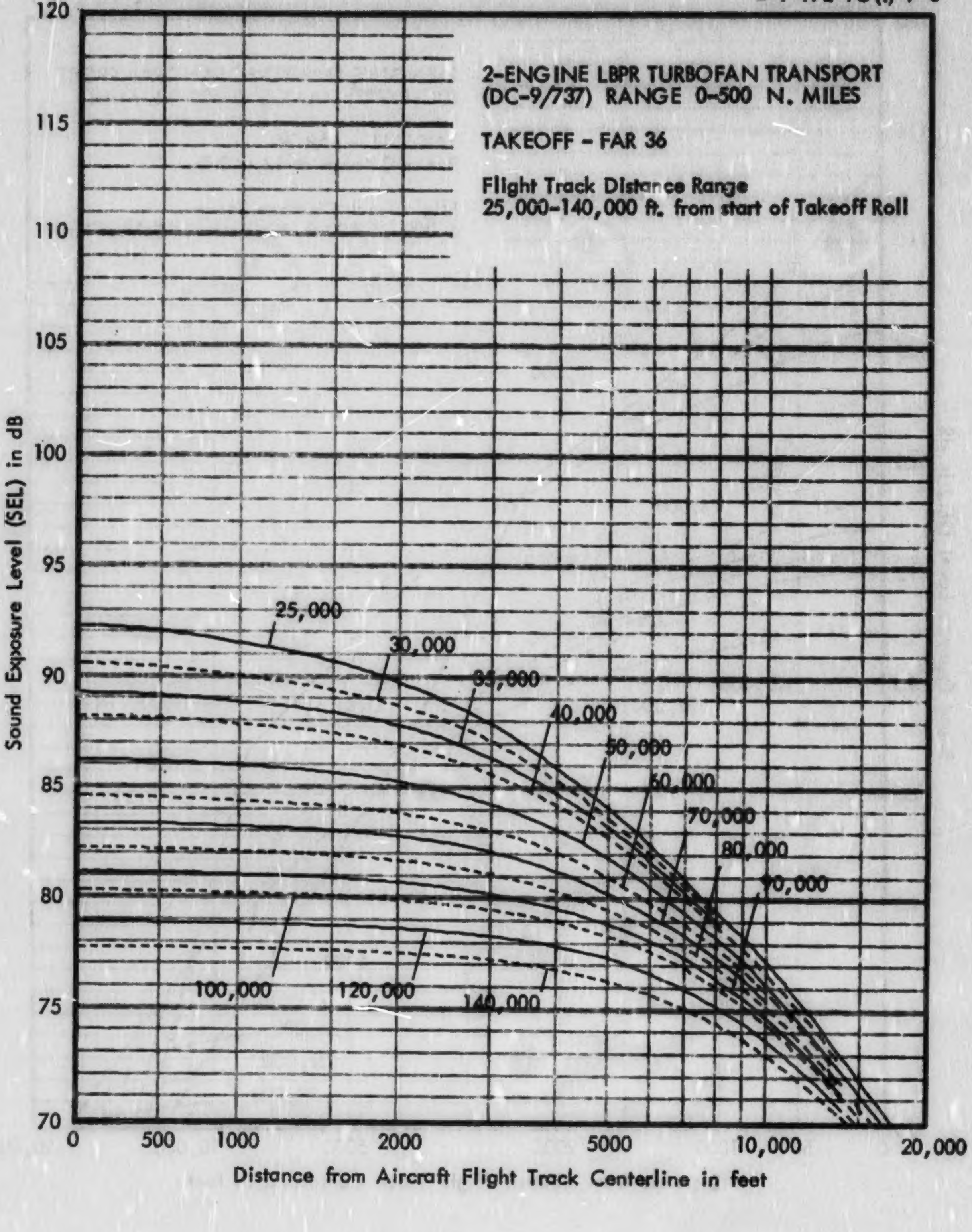


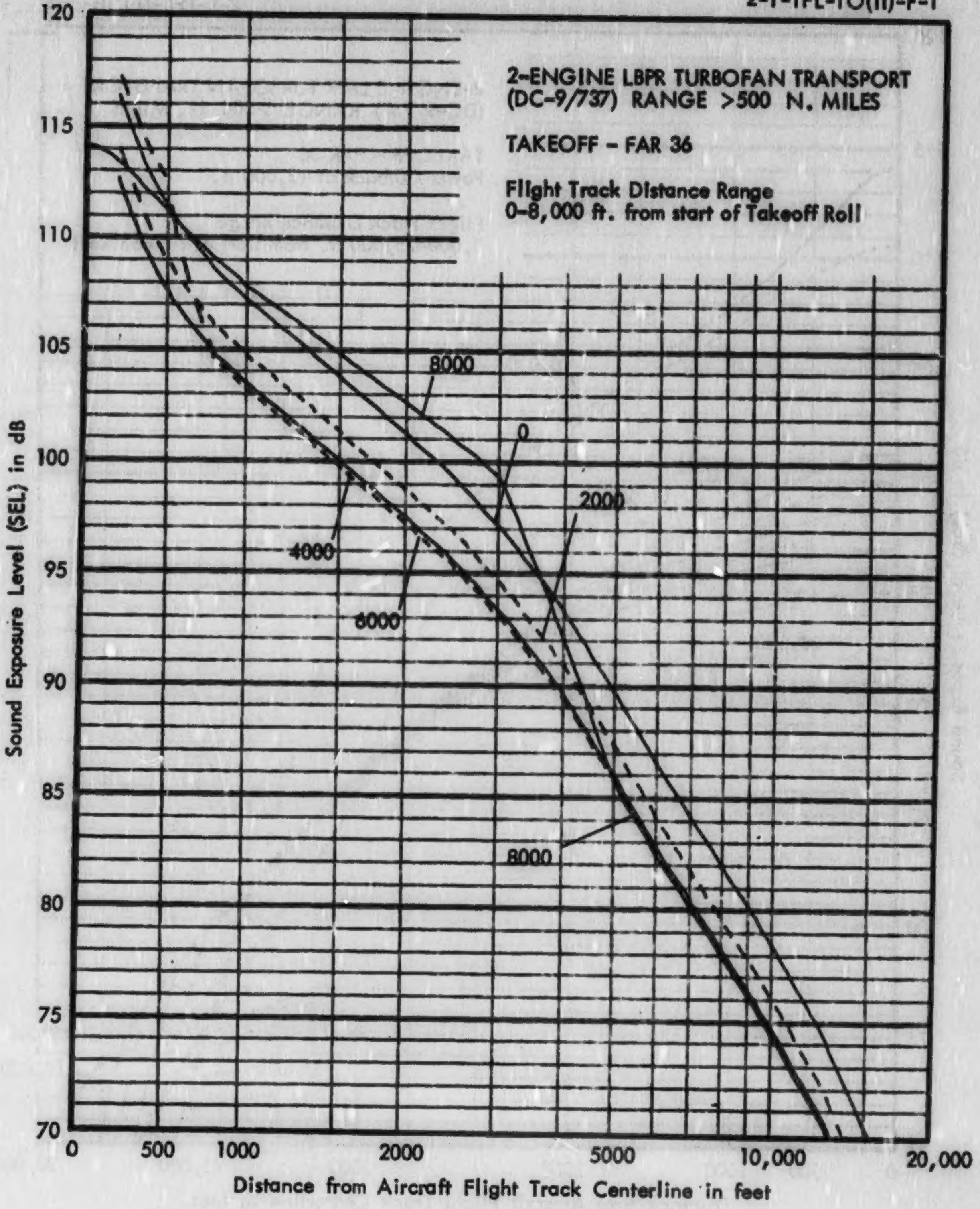
2-T-TFL-TO(II)-N-3

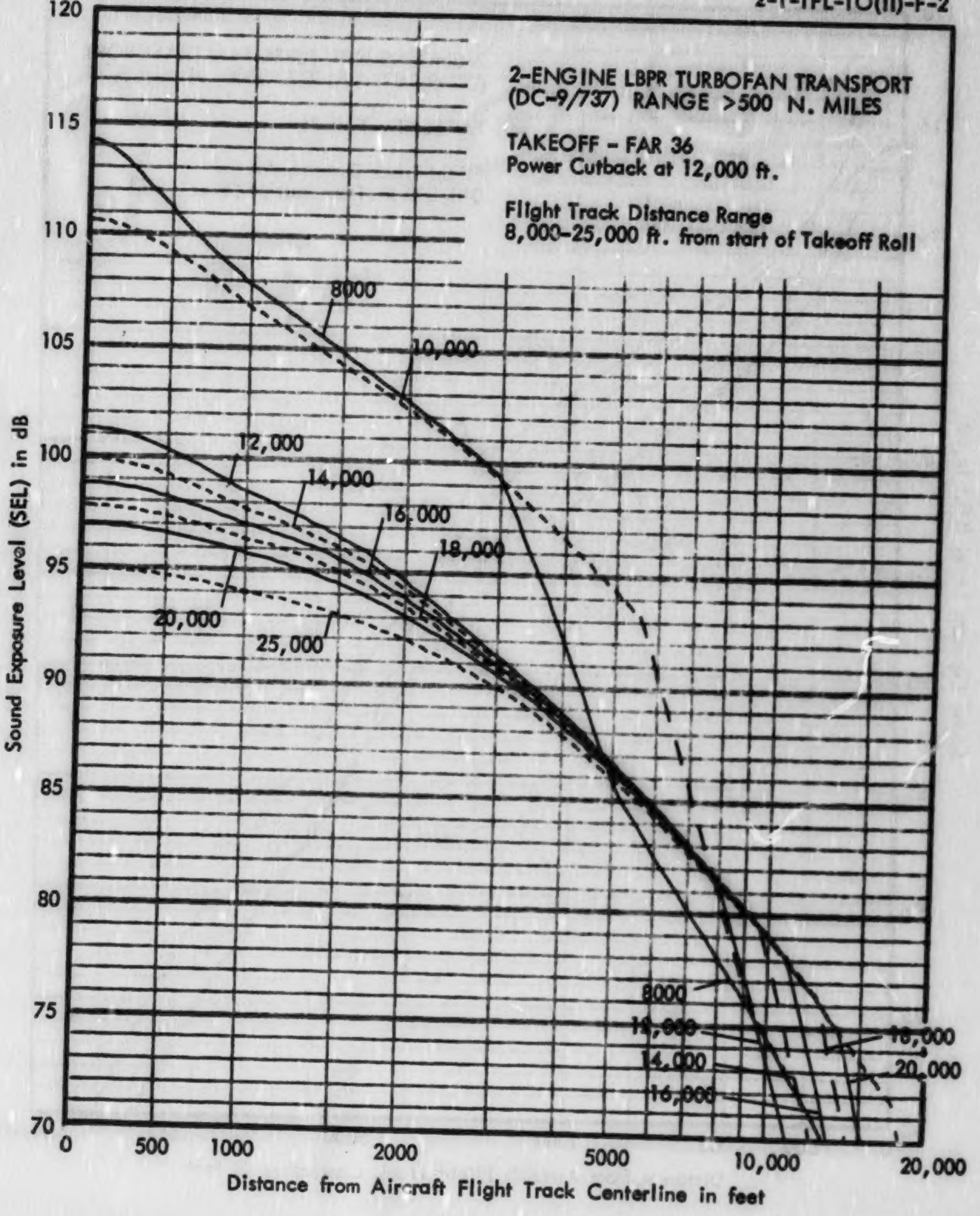



2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-6,000 ft. from start of Takeoff Roll
6000
0
2000
4000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

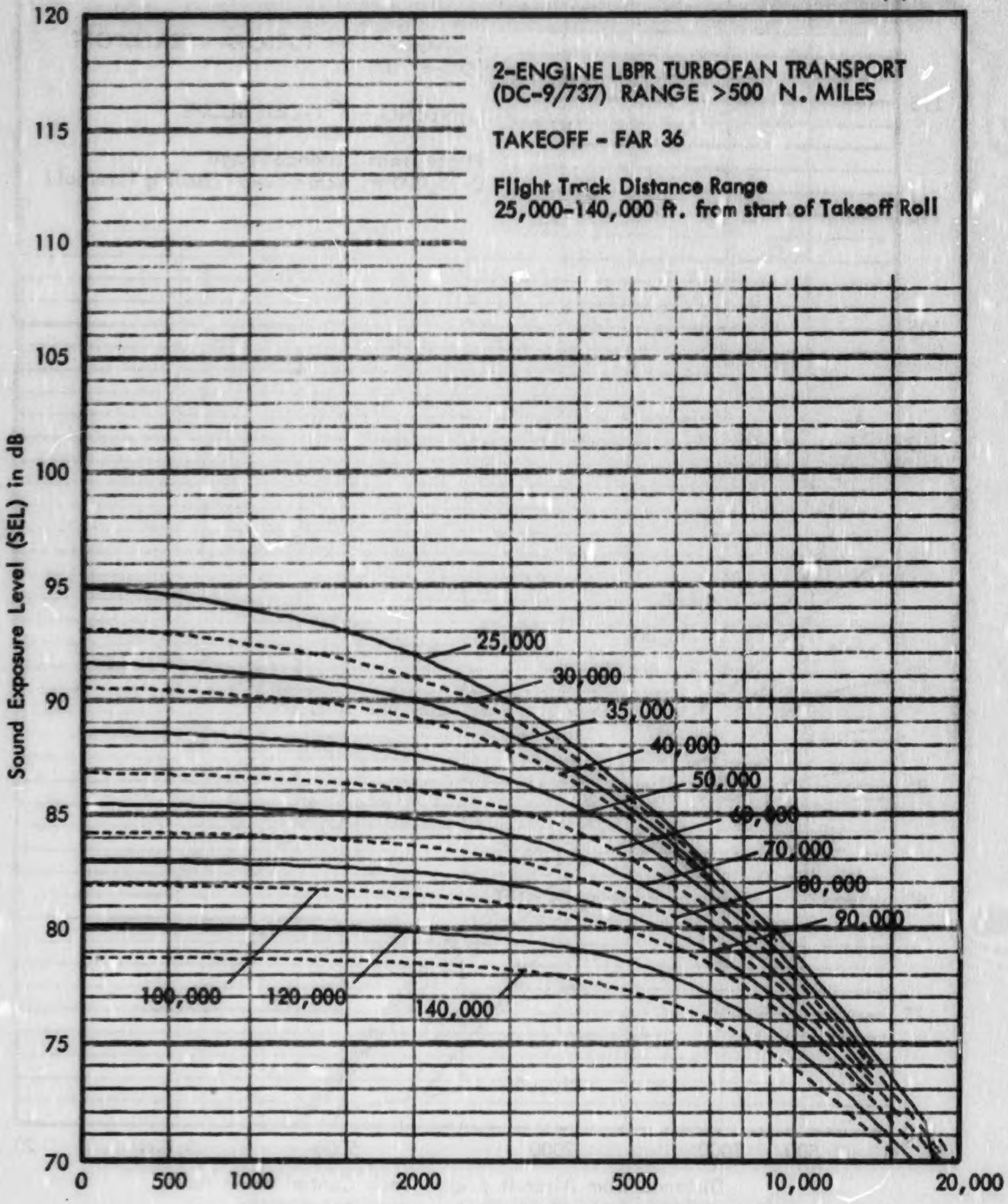

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Power Cutback at 12,000 ft.
Flight Track Distance Range
6,000-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
8000
10,000
6000
12,000
14,000
16,000
18,000

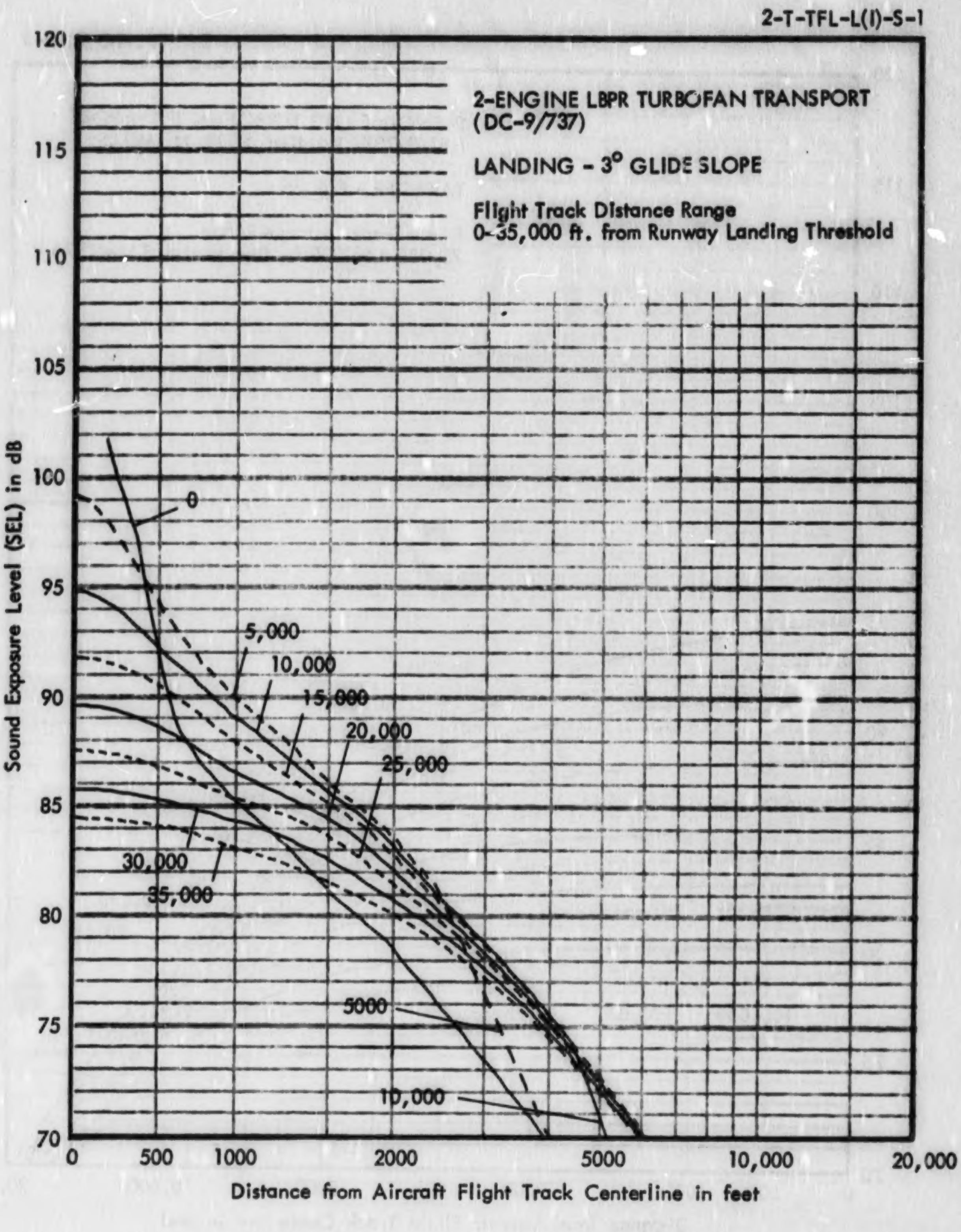

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
25,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
25,000
30,000
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
120,000
140,000

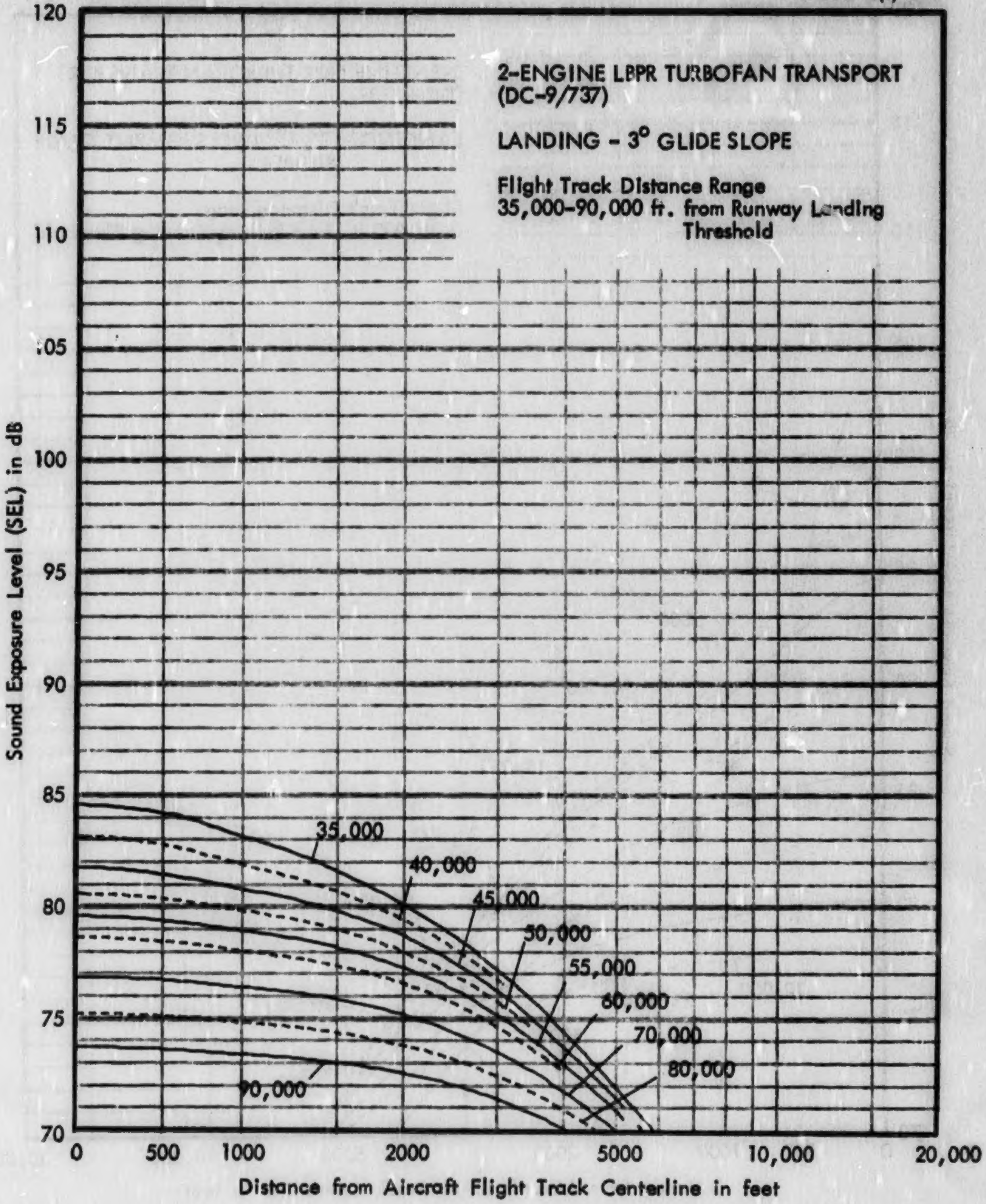

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
8000
0
2000
4000
6000
8000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

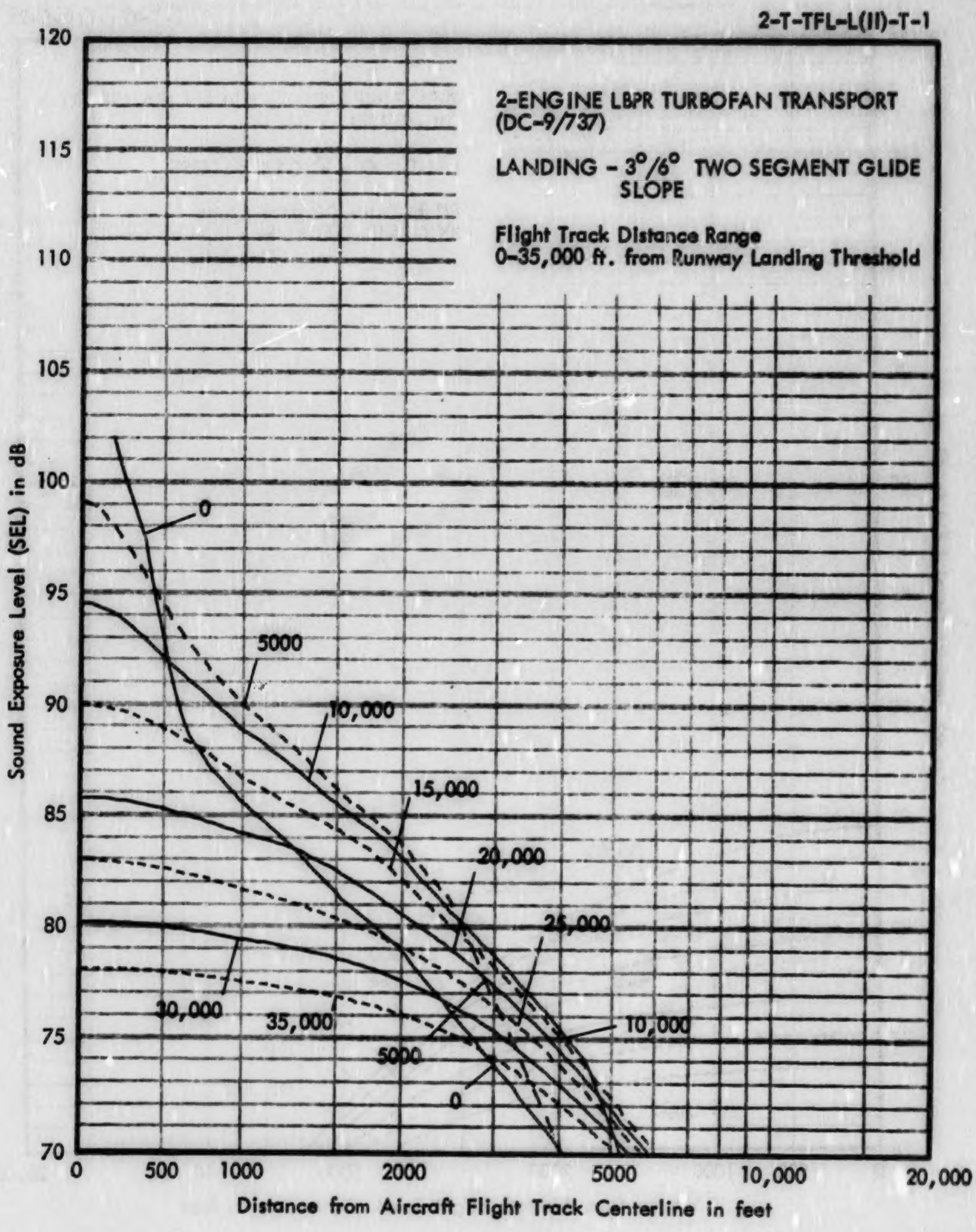

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - FAR 36
Power Cutback at 12,000 ft.
Flight Track Distance Range
8,000-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
8000
12,000
14,000
16,000
18,000
20,000

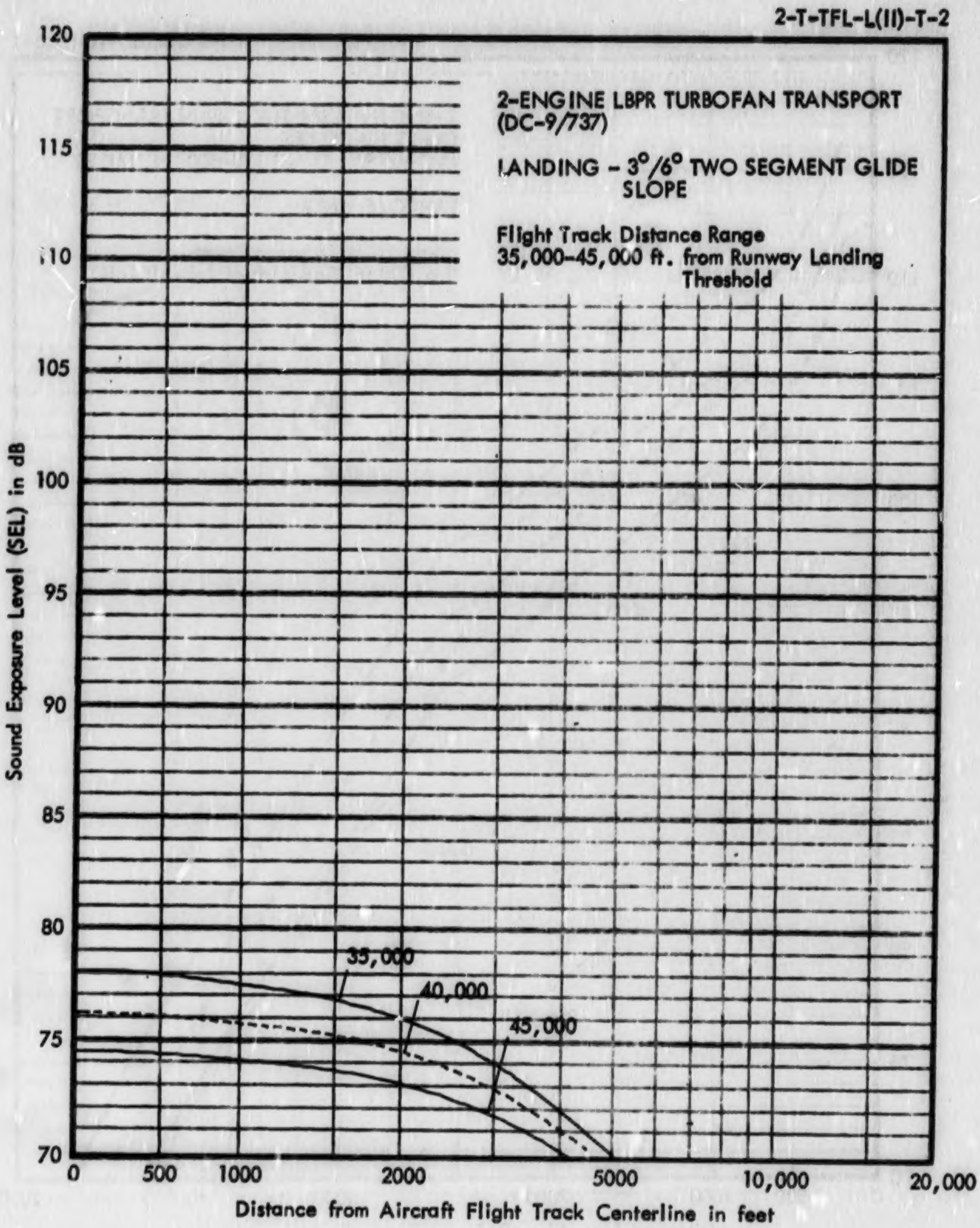
2-T-TFL-TO(II)-F-3

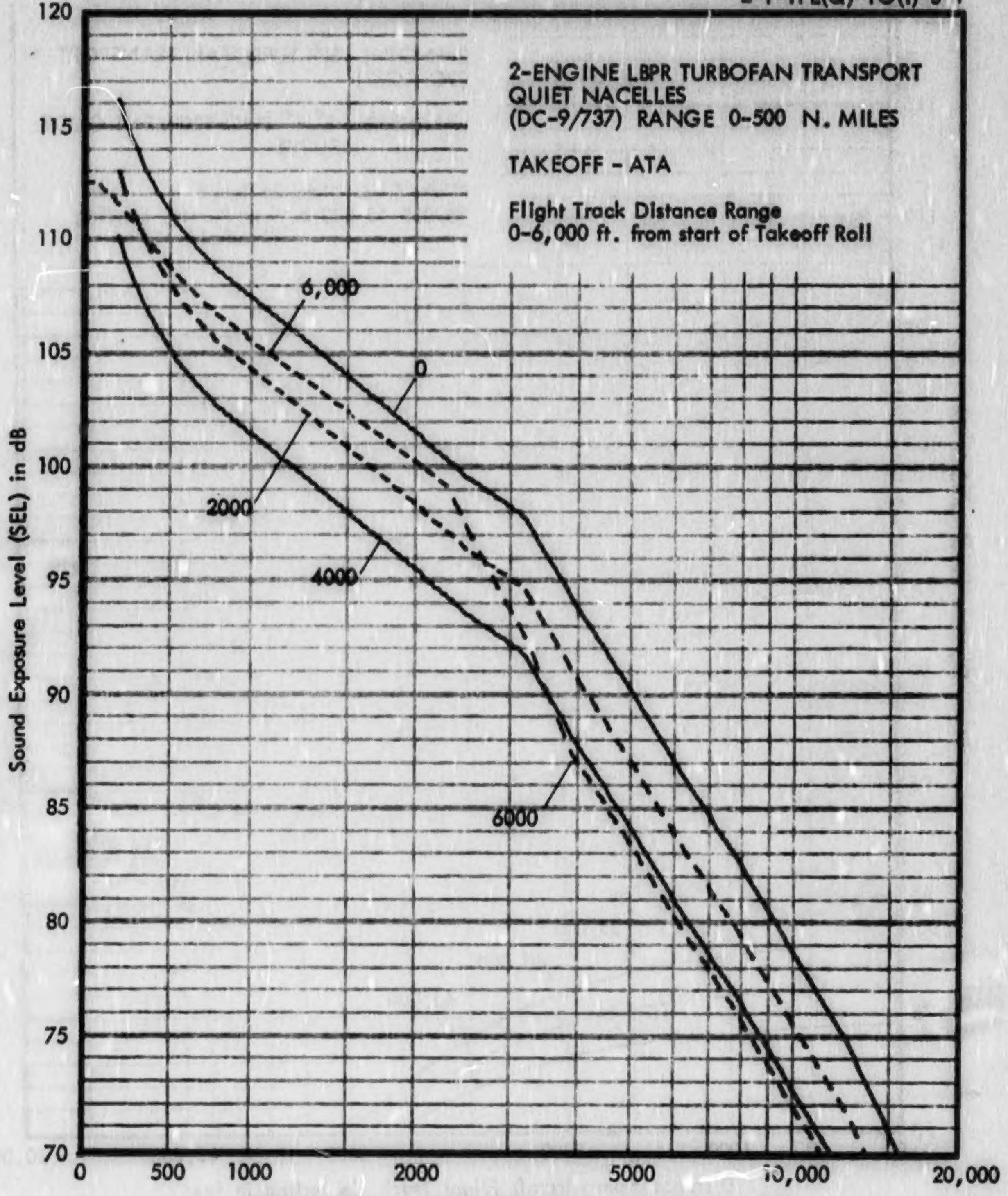


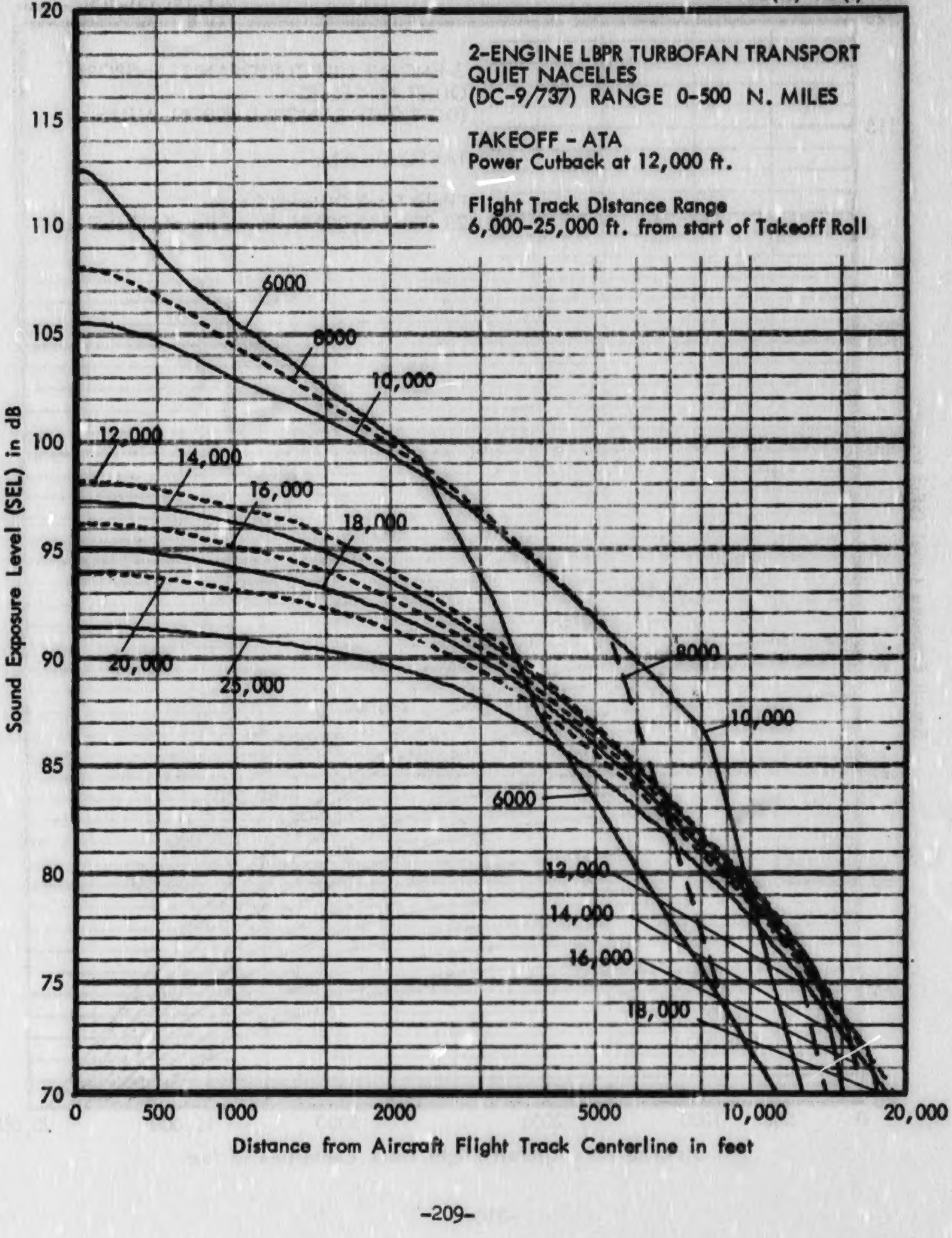

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
5000
10,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


2-ENGINE LBPR TURBOFAN TRANSPORT (DC-9/737)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range 35,000-90,000 ft. from Runway Landing Threshold
35,000
40,000
45,000
50,000
55,000
60,000
70,000
80,000
90,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

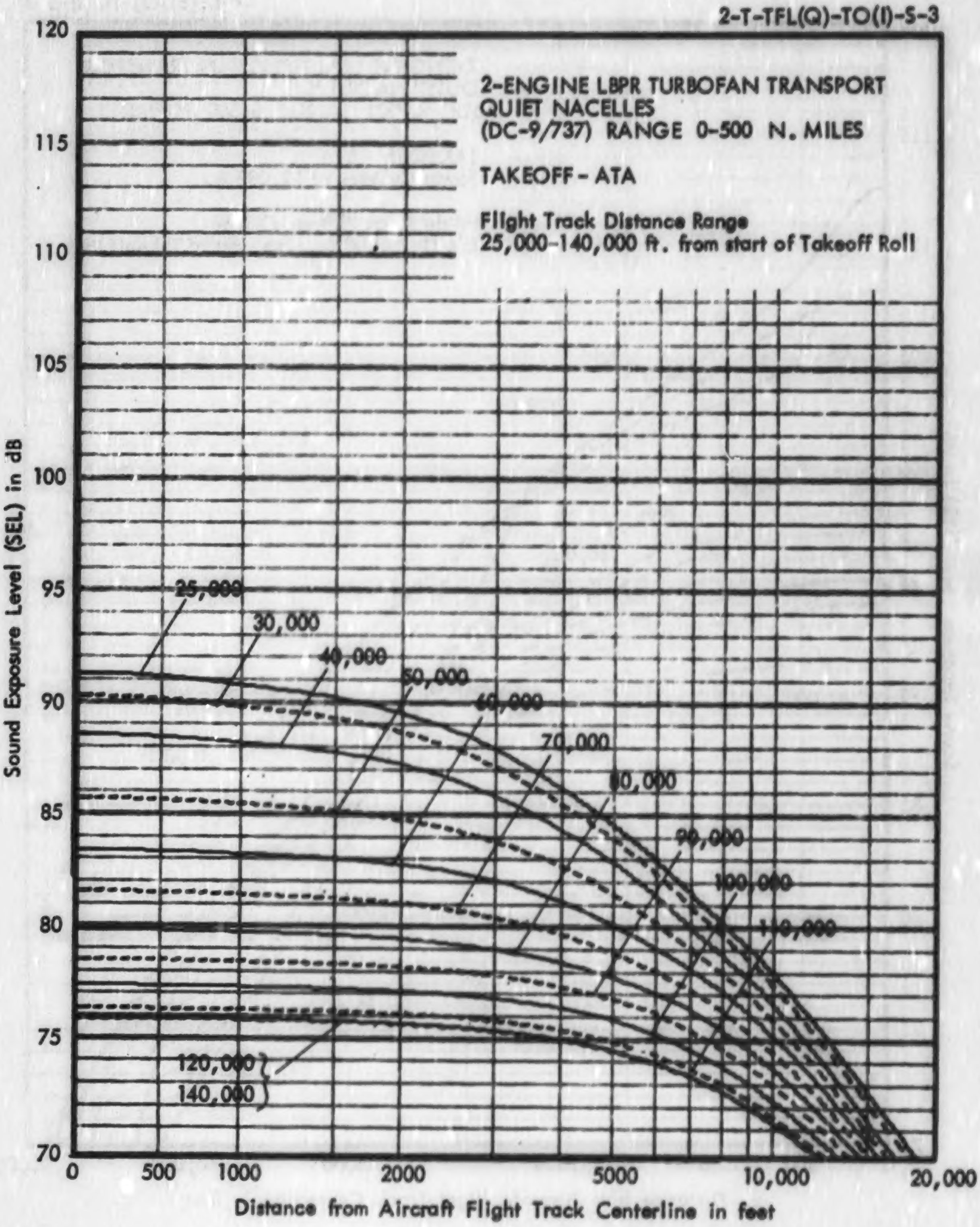

2-ENGINE LBPR TURBOFAN TRANSPORT (DC-9/737)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
10,000
5000
0

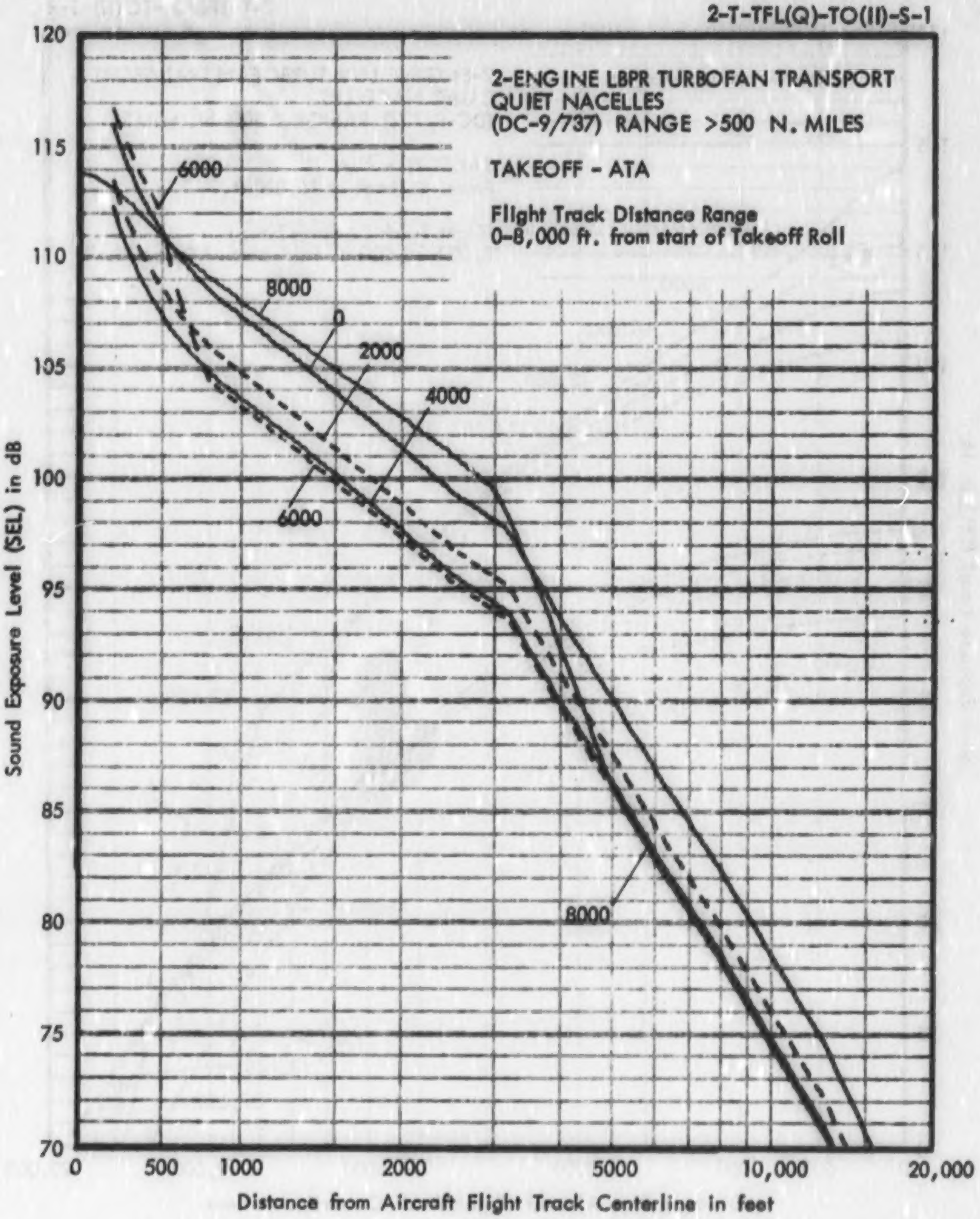

2-ENGINE LBPR TURBOFAN TRANSPORT
(DC-9/737)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range
35,000-45,000 ft. from Runway Landing Threshold
35,000
40,000
45,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

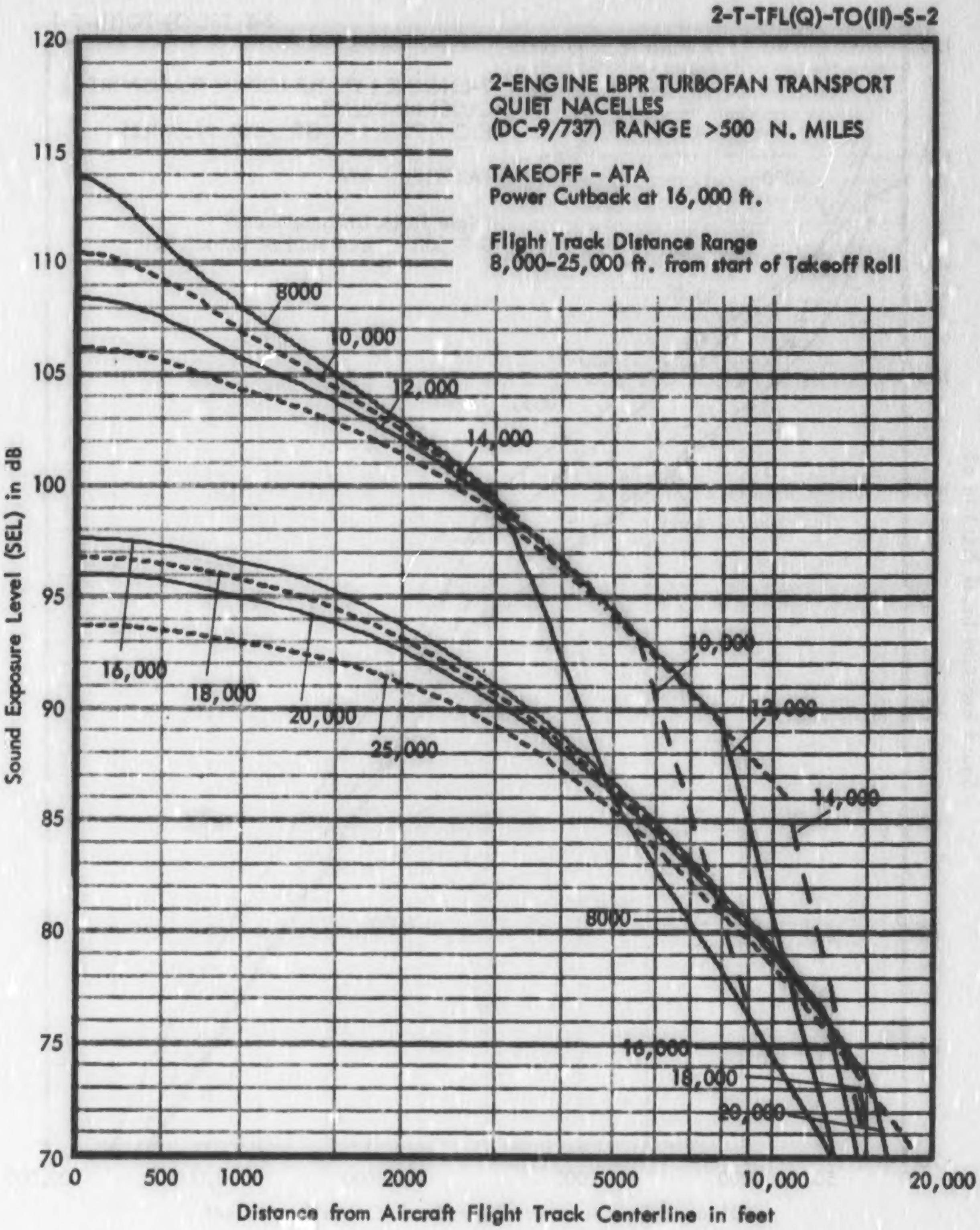

2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-6,000 ft. from start of Takeoff Roll
6,000
0
2000
4000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE 0-500 N. MILES
TAKEOFF - ATA
Power Cutback at 12,000 ft.
Flight Track Distance Range
6,000-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
6000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
8000
10,000
6000
12,000
14,000
16,000
18,000

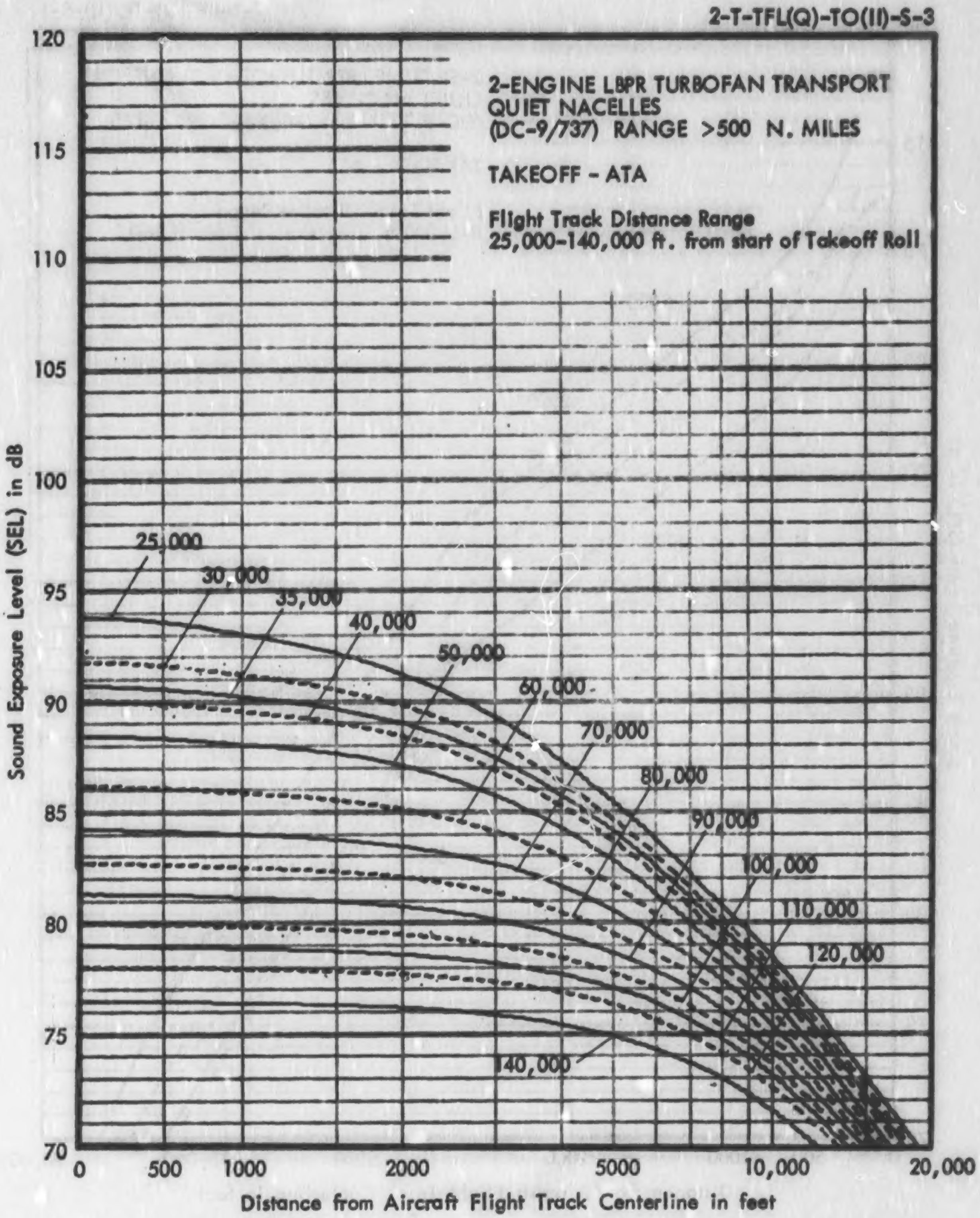
2-T-TFL(Q)-TO(I)-S-3

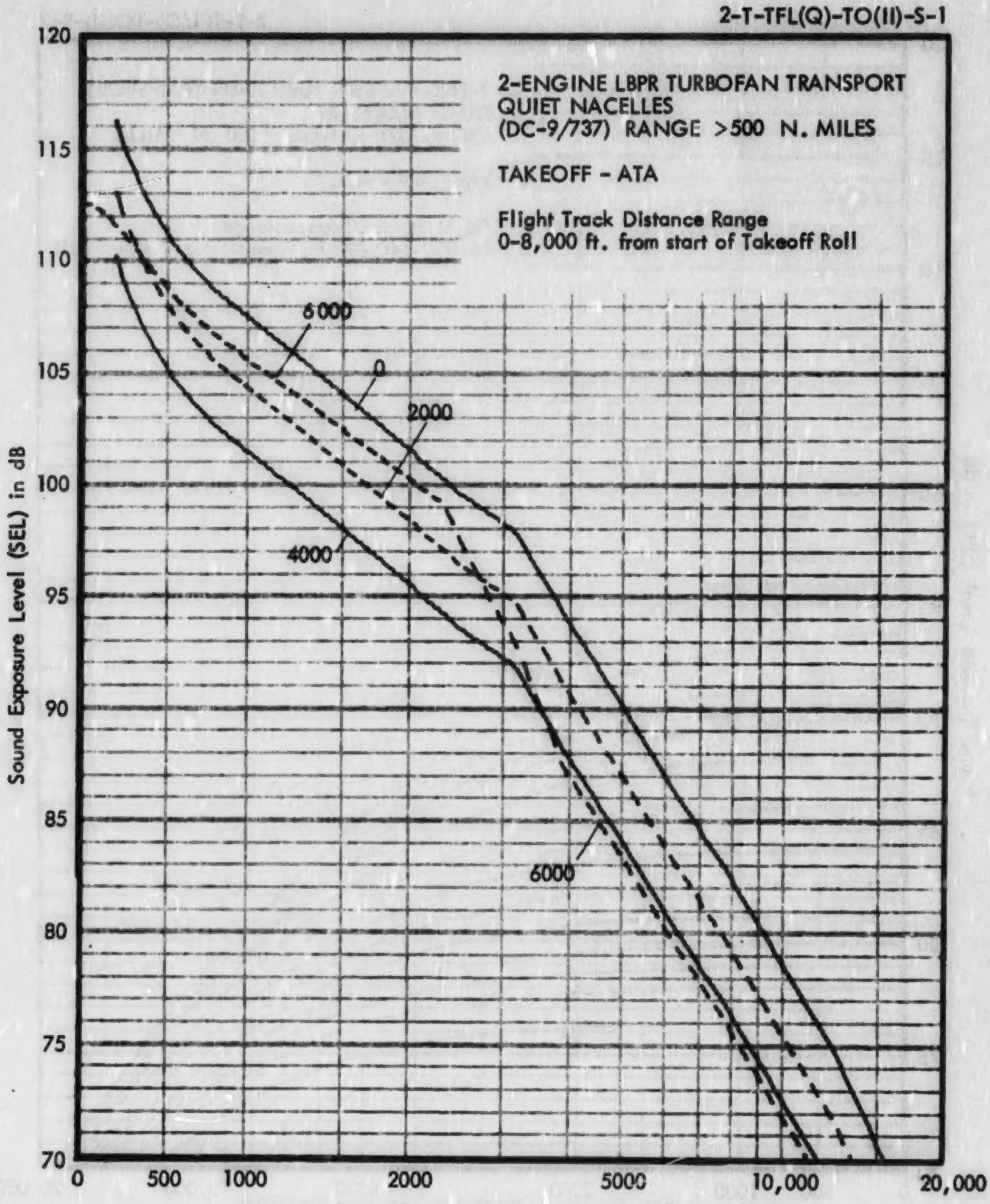



2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
6000
8000
0
2000
4000
6000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

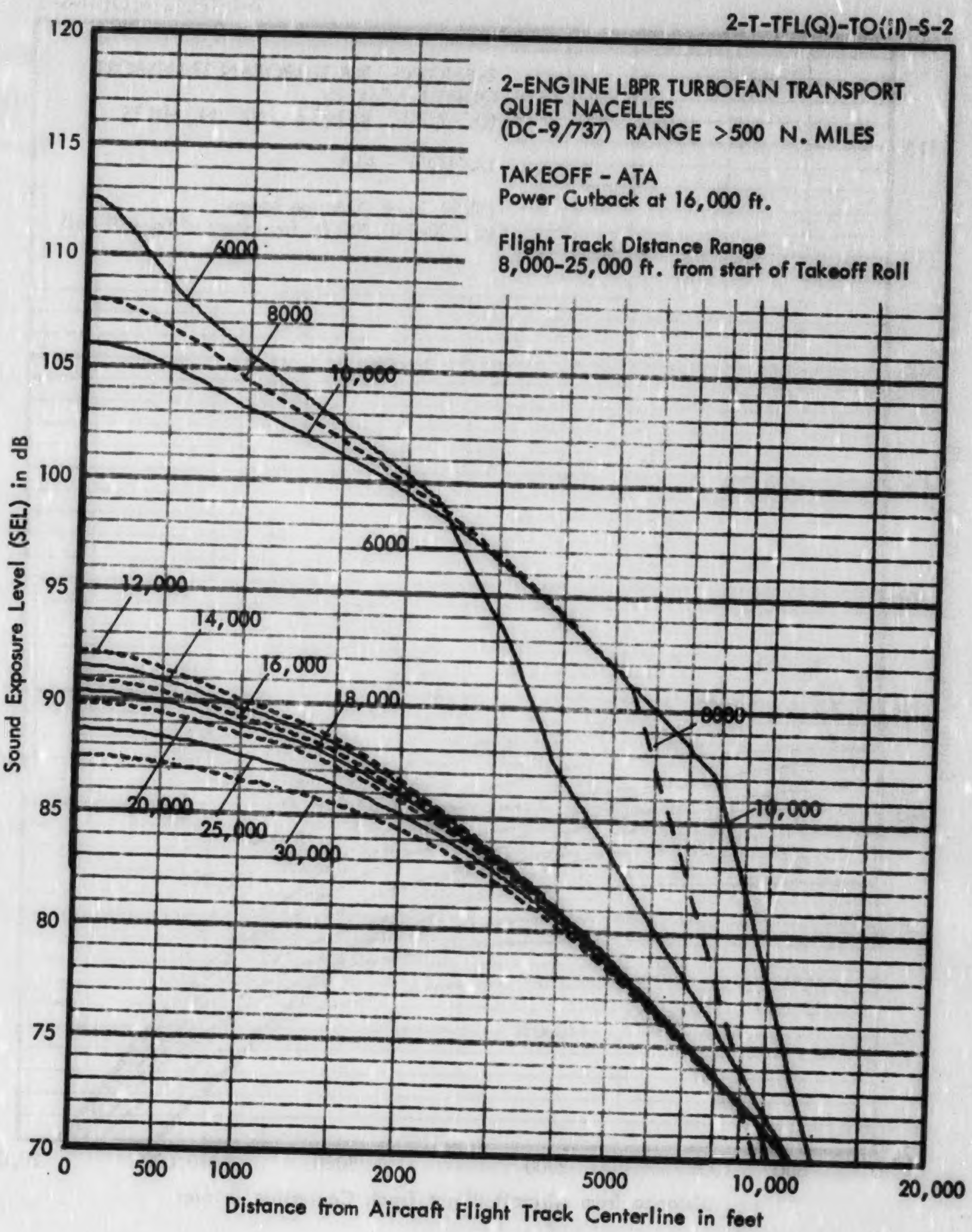

2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - ATA
Power Cutback at 16,000 ft.
Flight Track Distance Range
8,000-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
10,000
12,000
14,000
8000
16,000
18,000
20,000

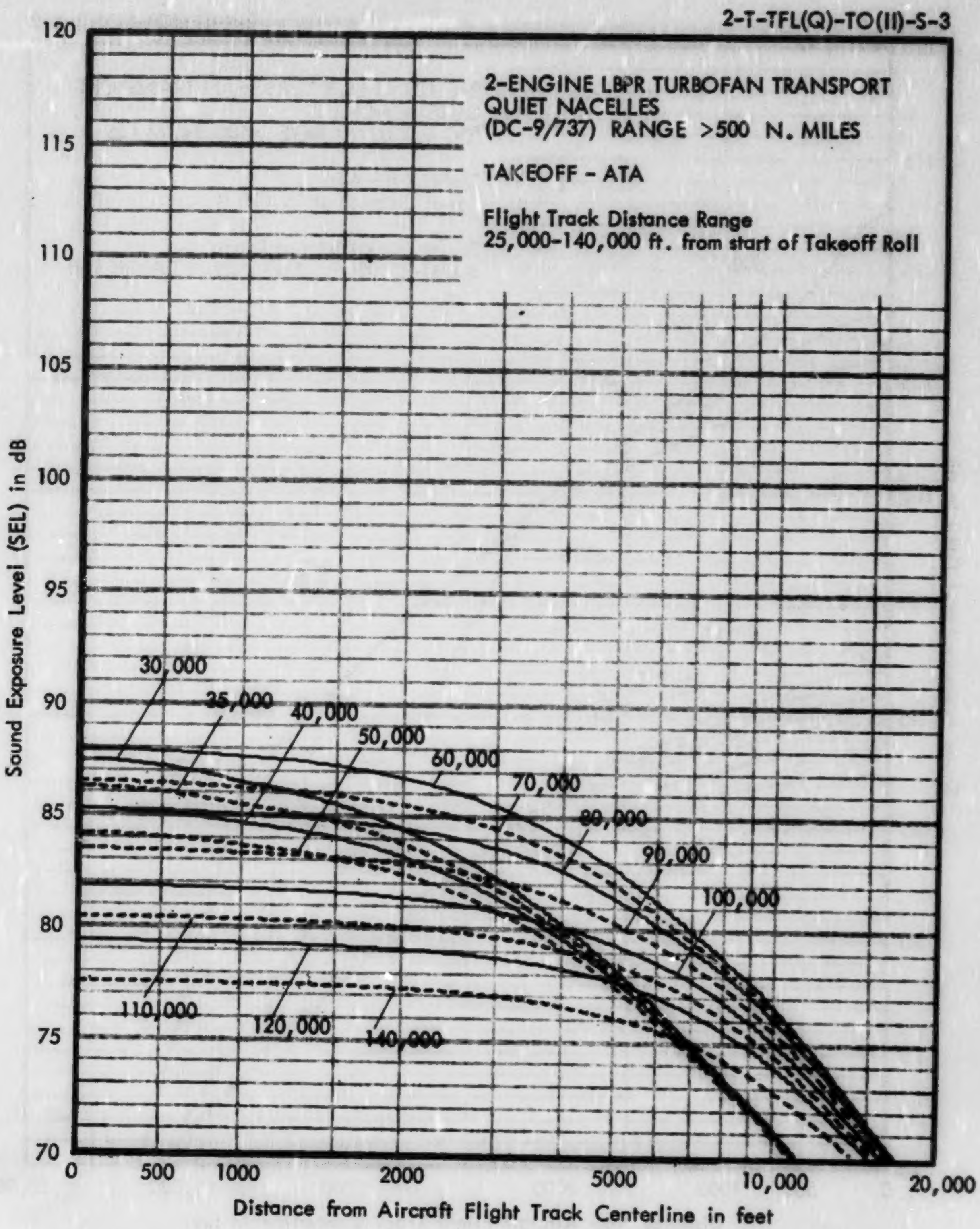
2-T-TFL(Q)-TO(II)-S-3



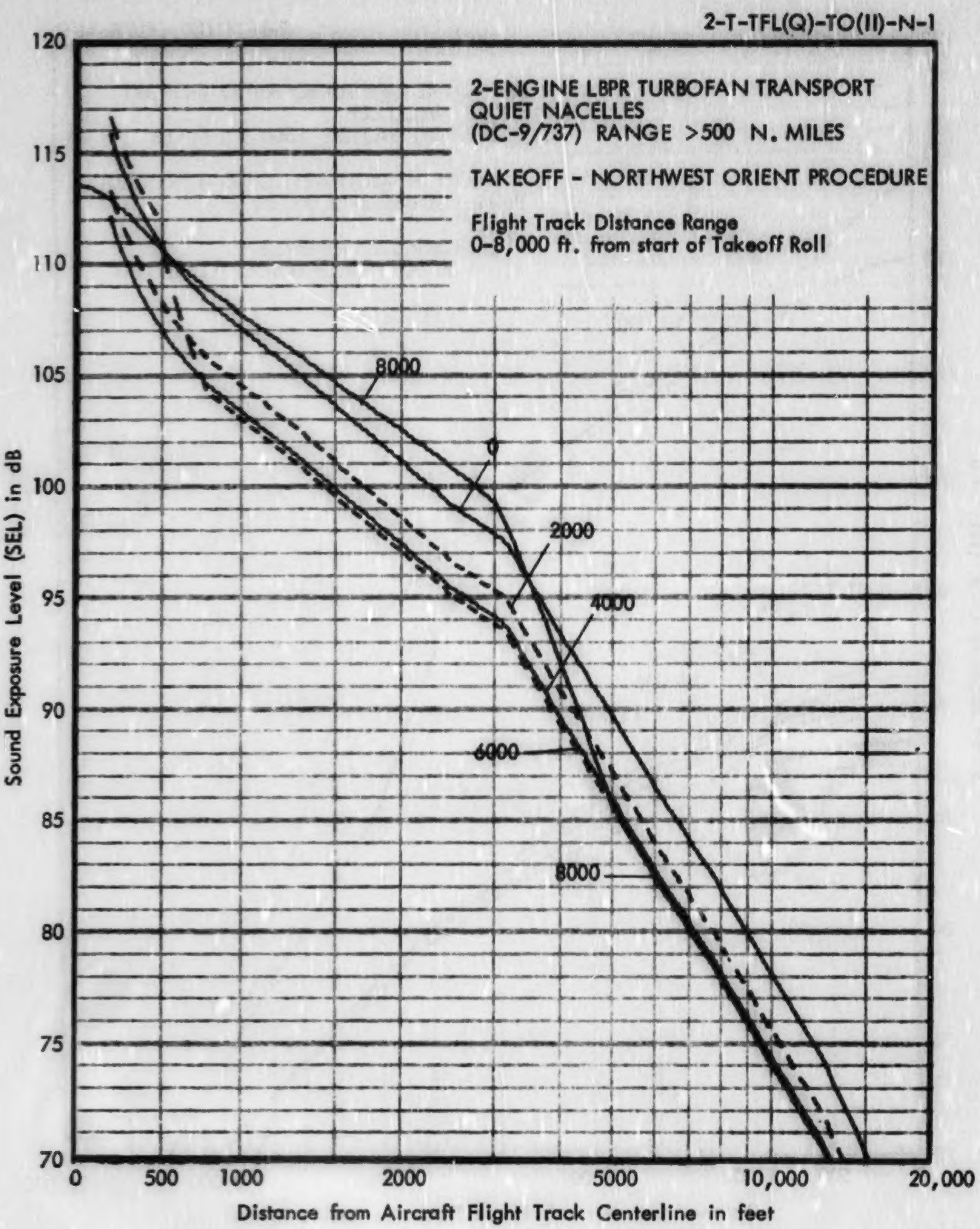

2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
6000
0
2000
4000
6000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

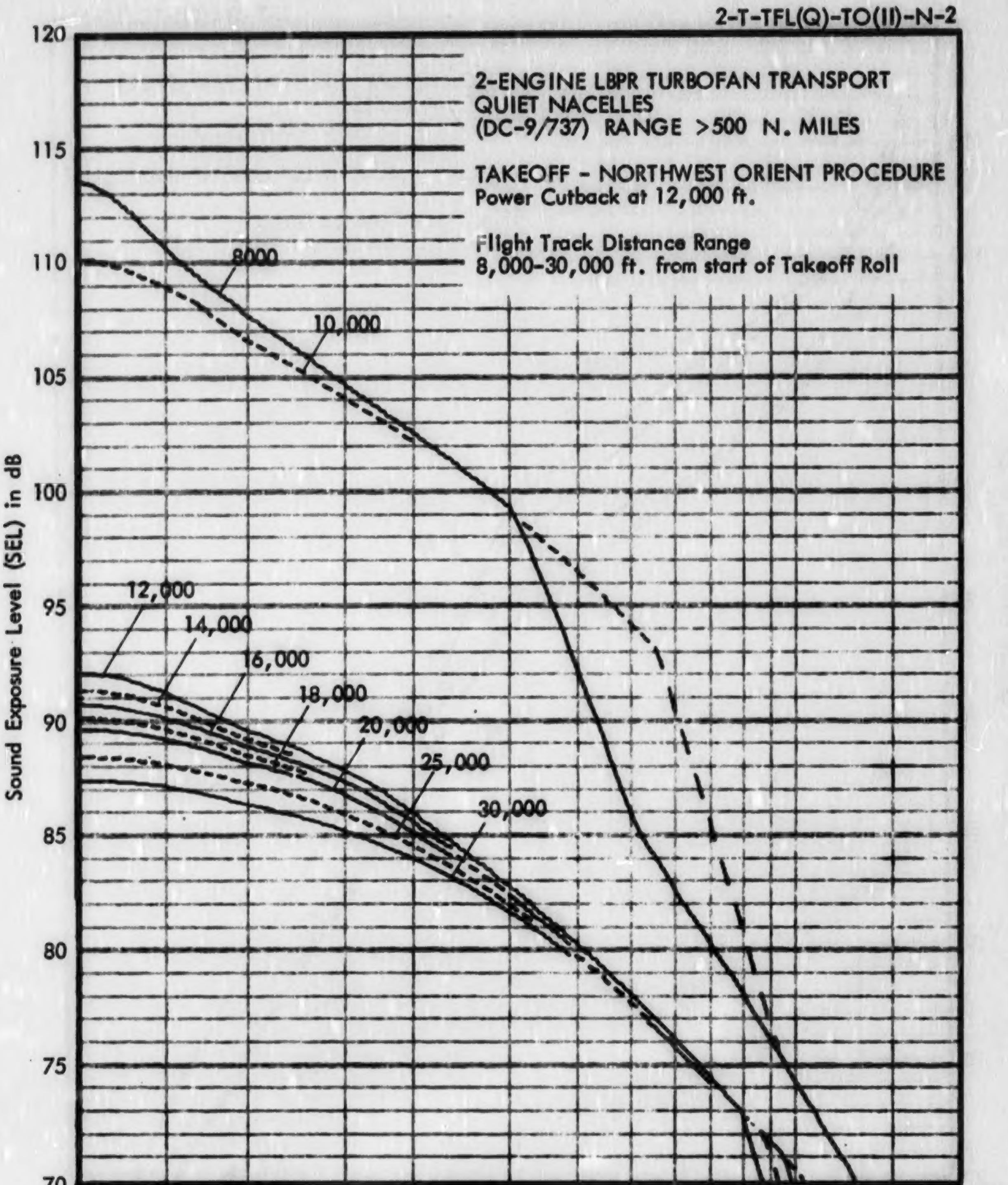
2-T-TFL(Q)-TO(II)-S-2



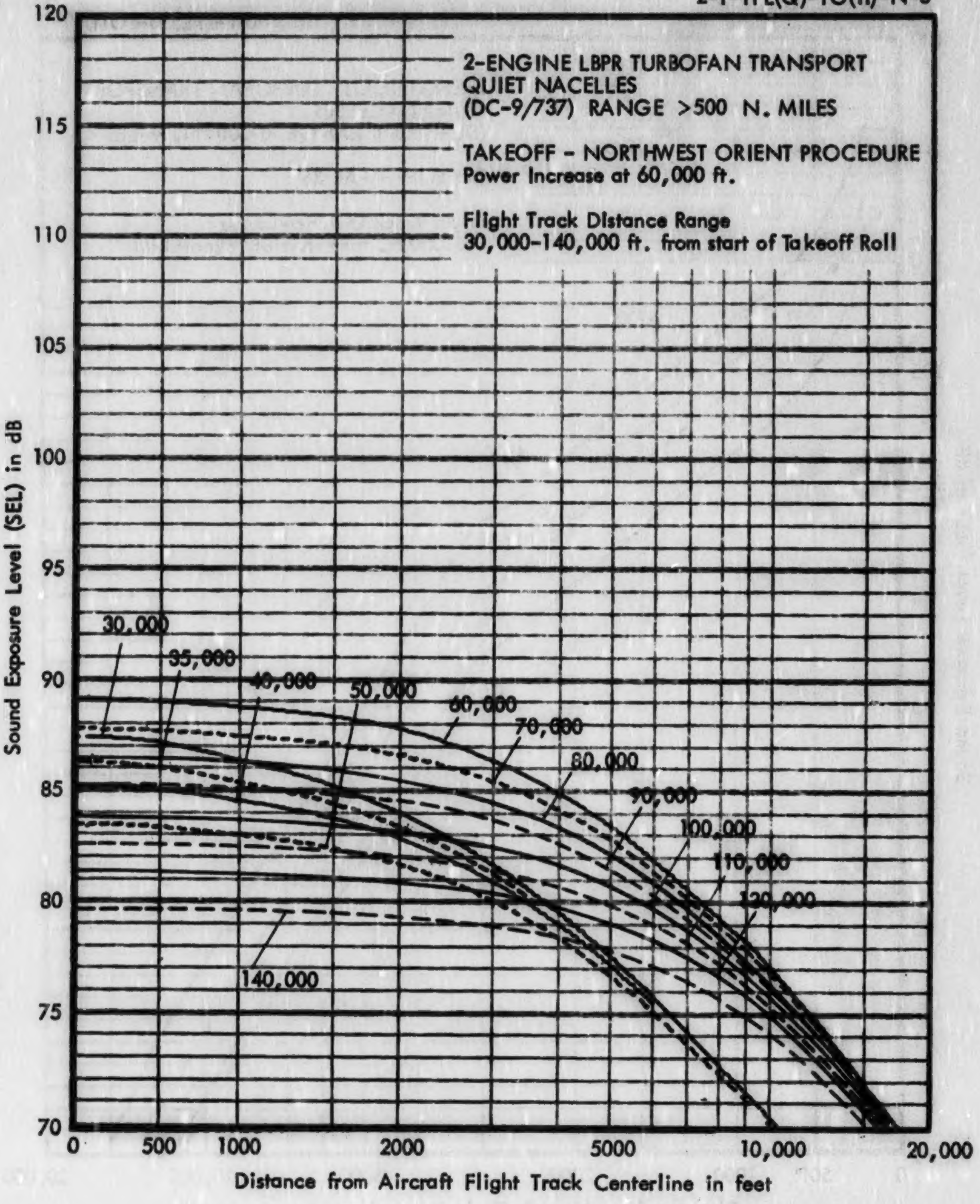

2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
25,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
30,000
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

2-T-TFL(Q)-TO(II)-N-1

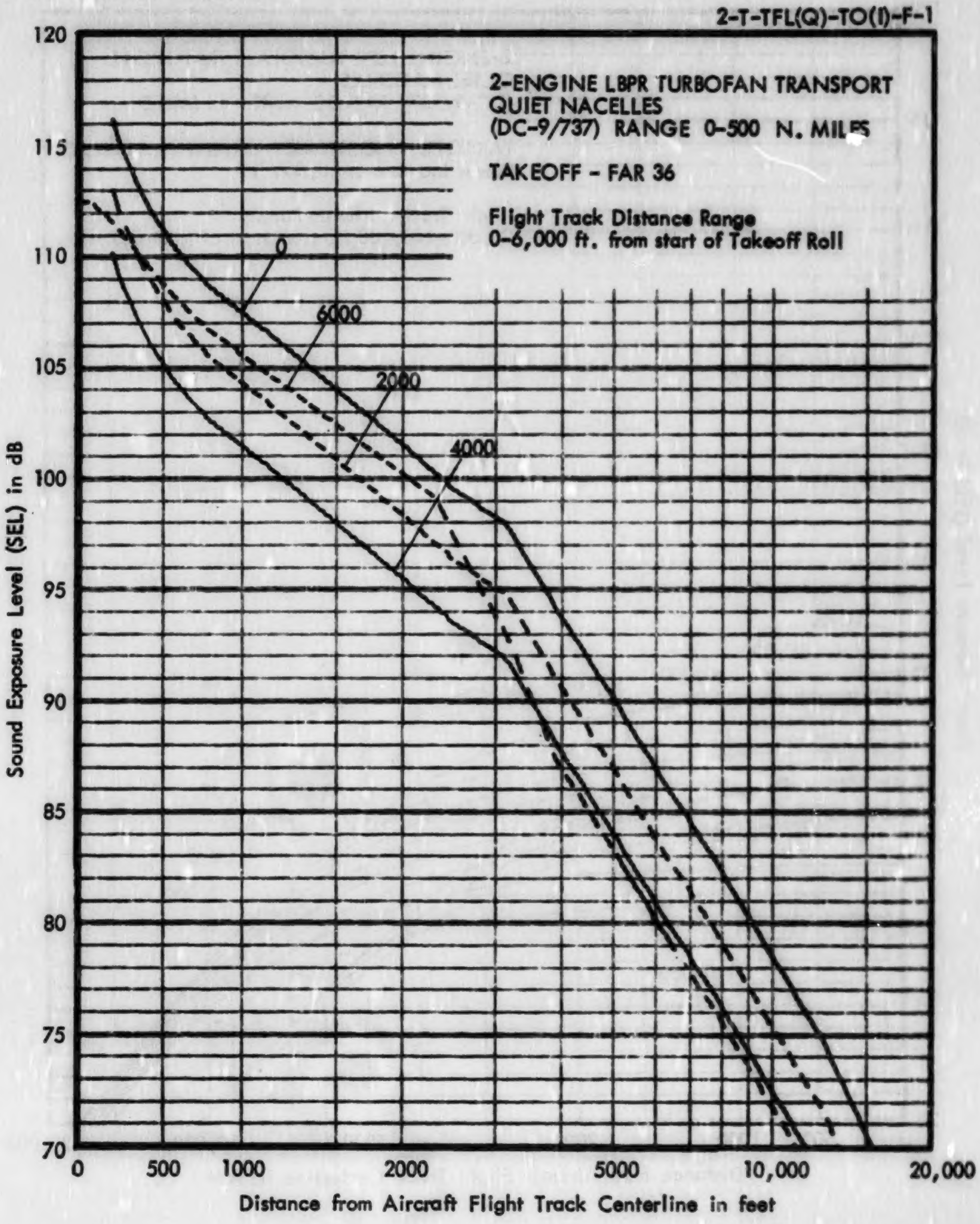



2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE >500 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 12,000 ft.
Flight Track Distance Range
8,000-30,000 ft. from start of Takeoff Roll
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

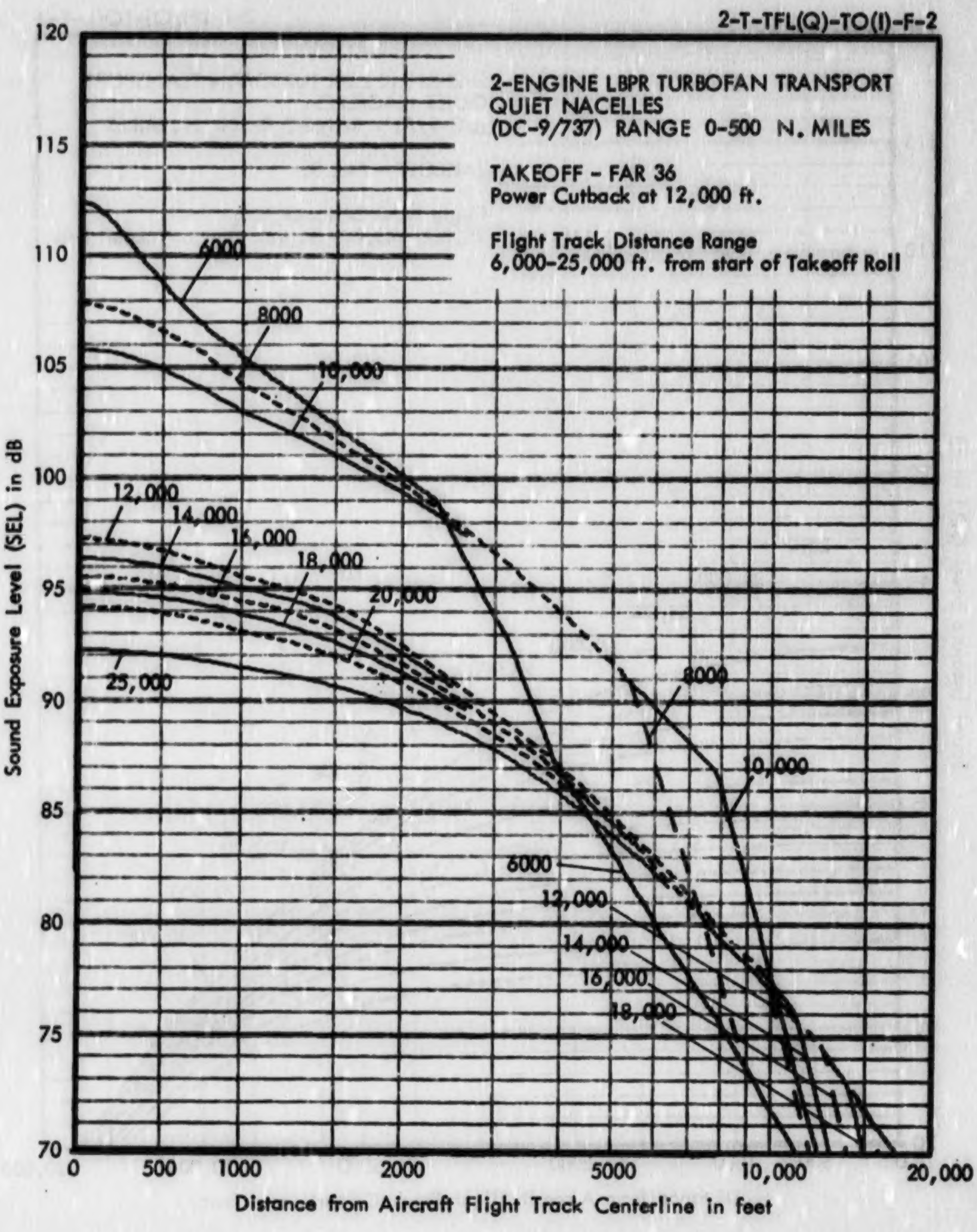
2-T-TFL(Q)-TO(II)-N-3



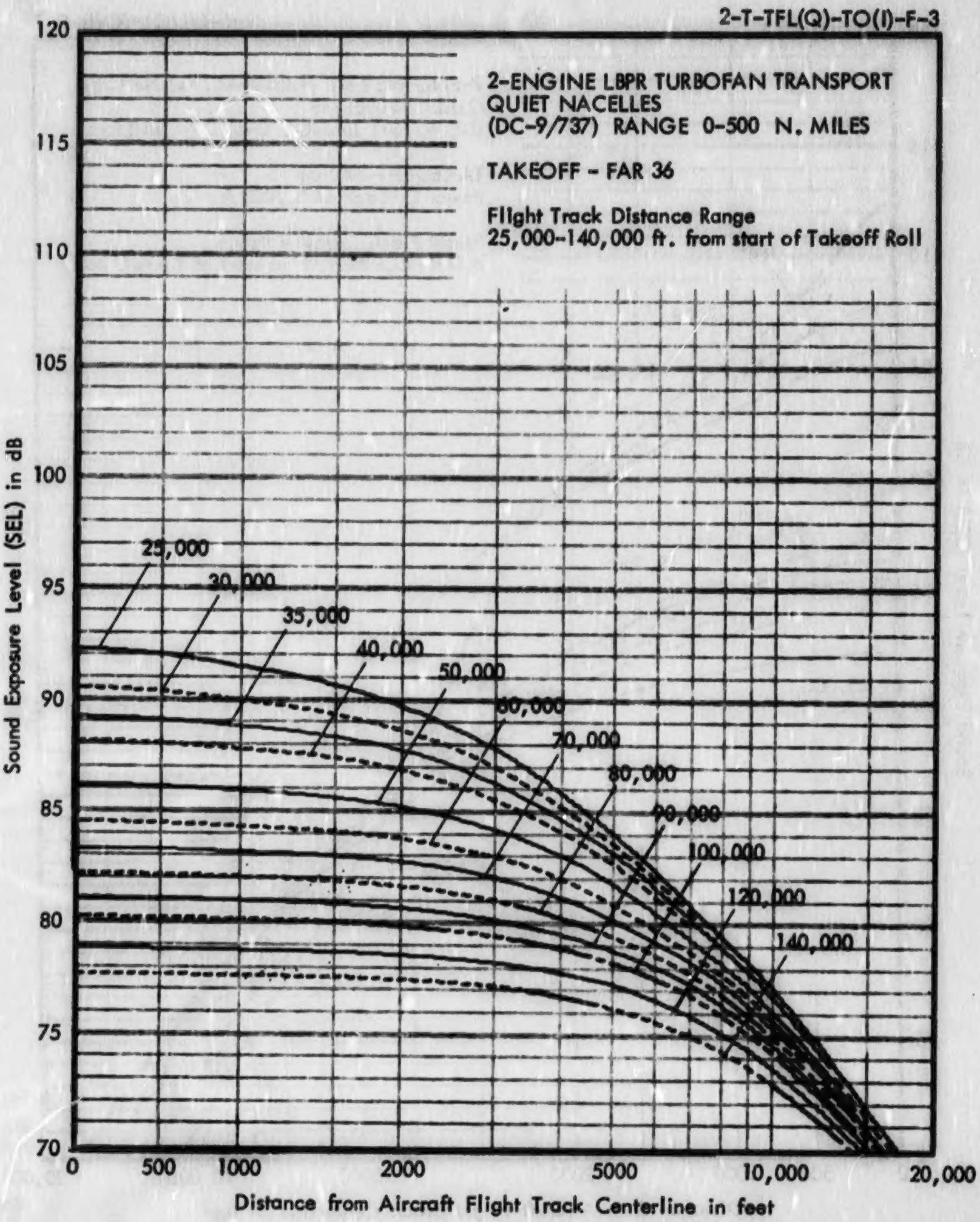
2-T-TFL(Q)-TO(I)-F-1



2-T-TFL(Q)-TO(I)-F-2



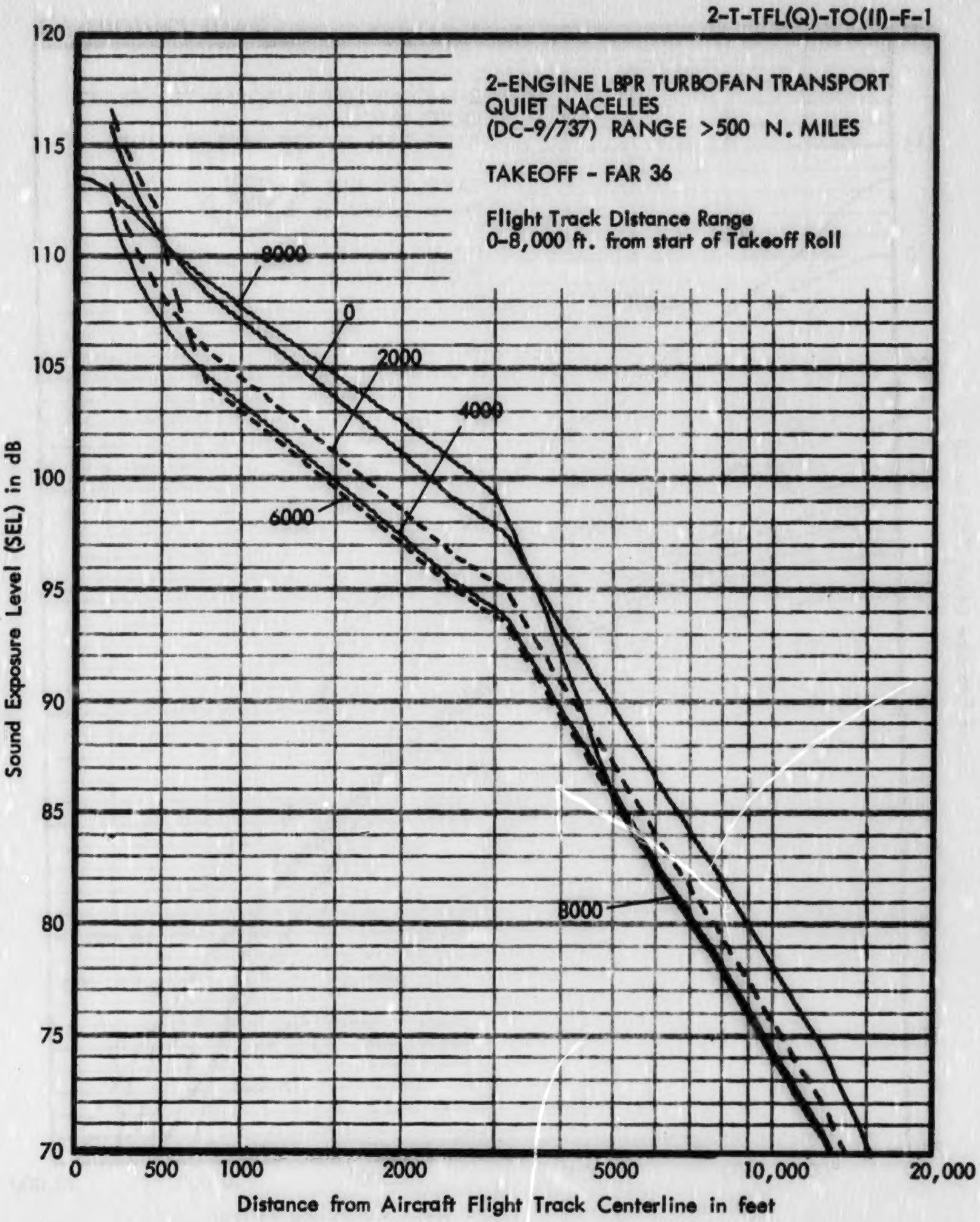
2-T-TFL(Q)-TO(I)-F-3


2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737) RANGE 0-500 N. MILES

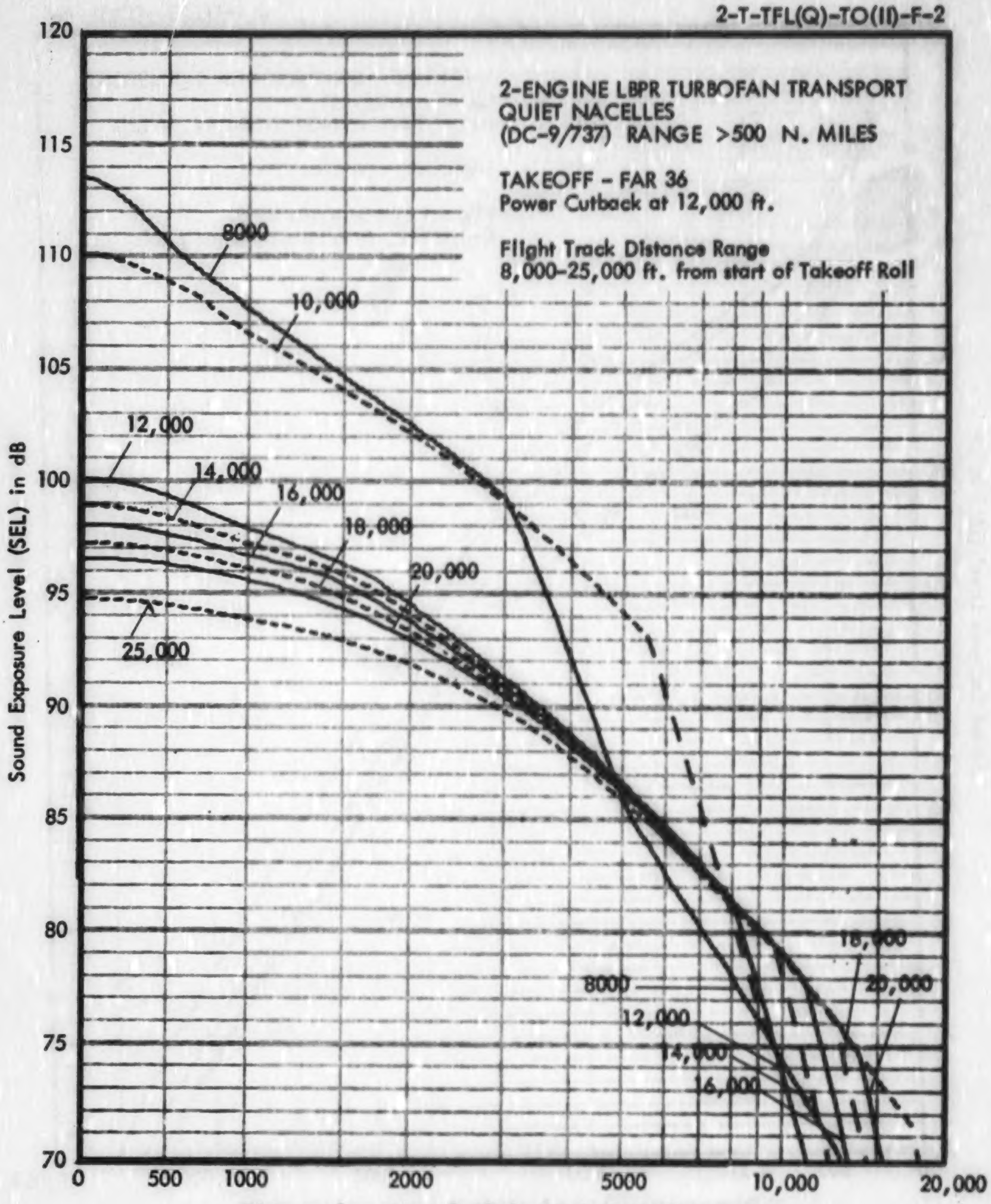
TAKEOFF - FAR 36

Flight Track Distance Range
25,000-140,000 ft. from start of Takeoff Roll

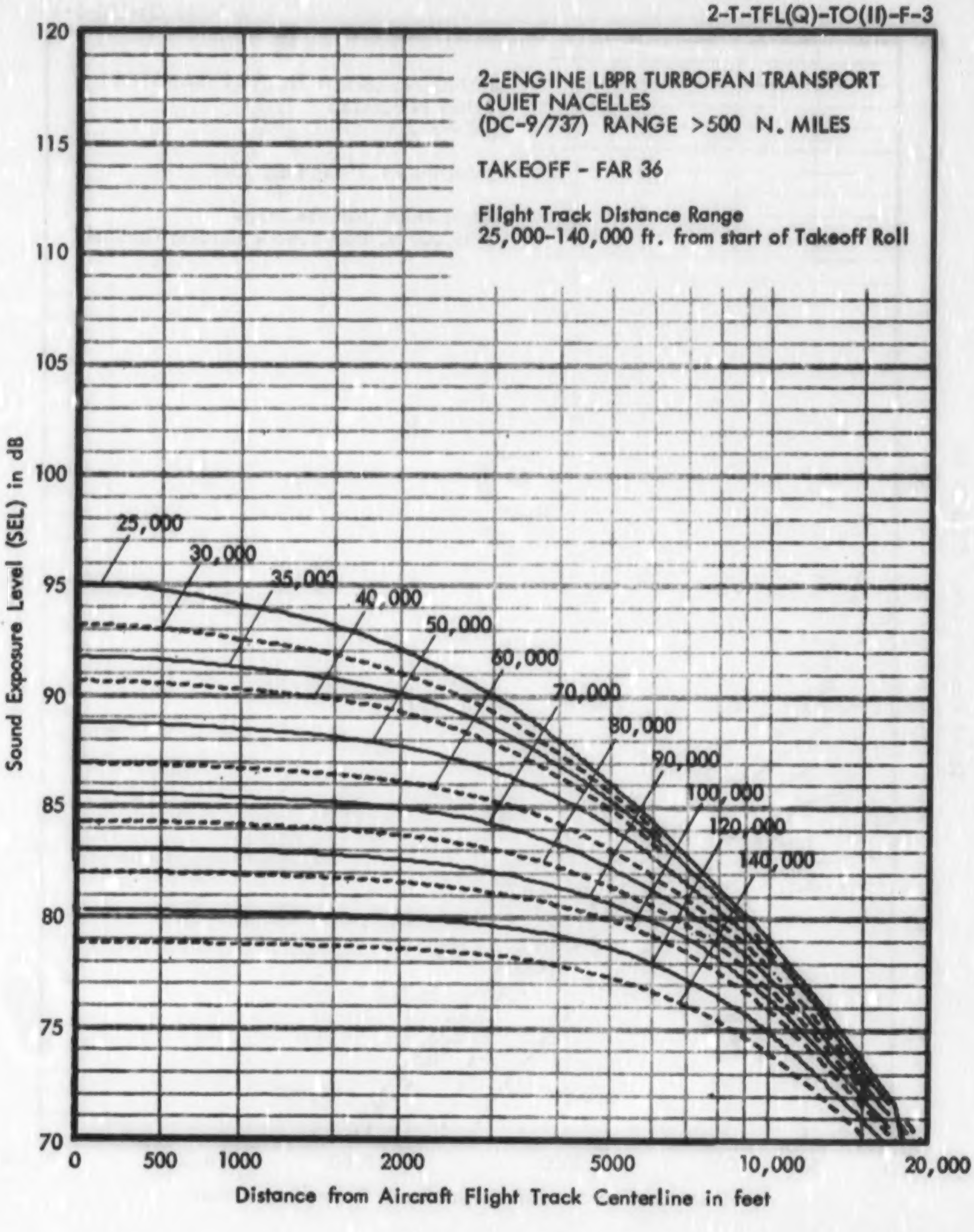
2-T-TFL(Q)-TO(II)-F-1



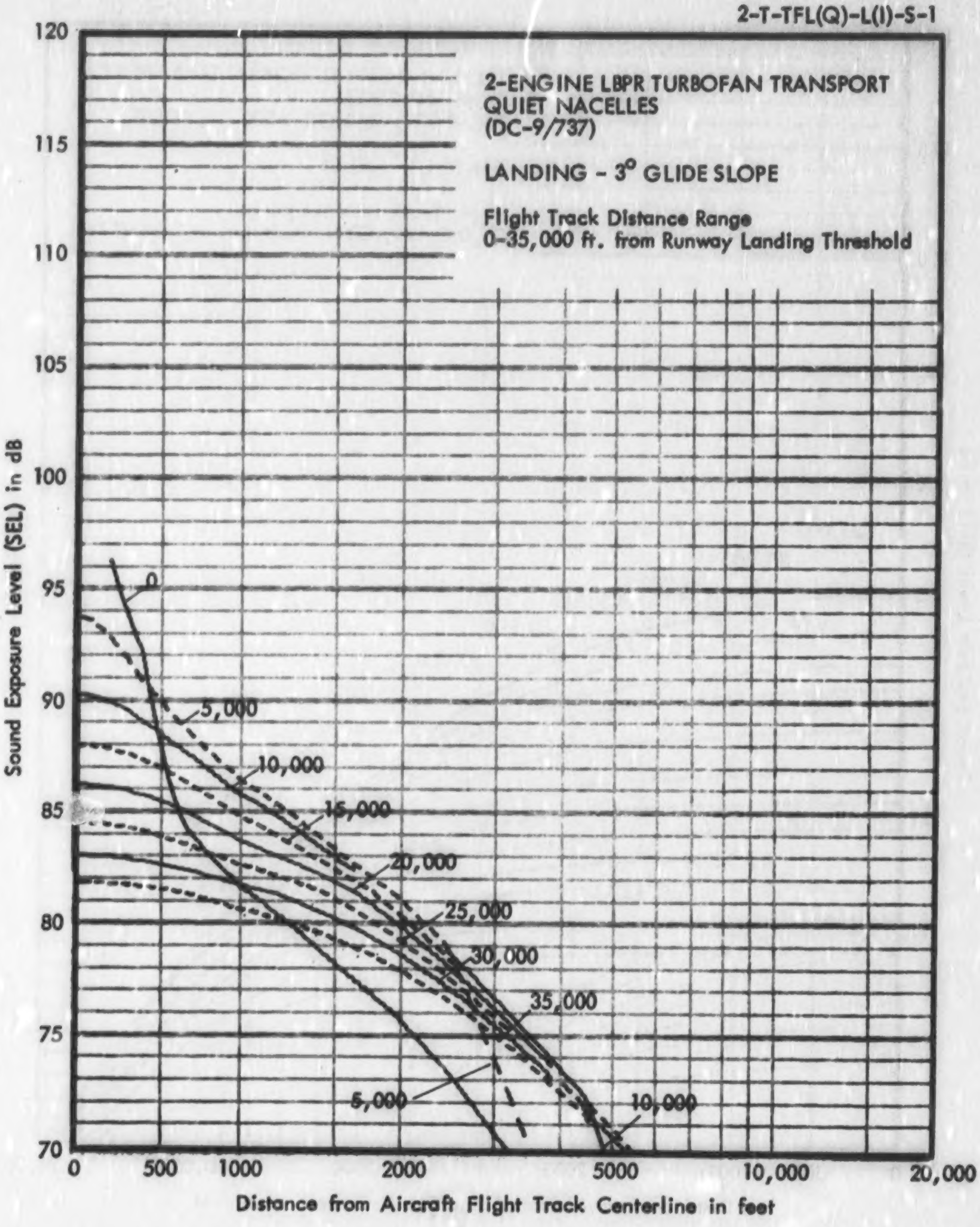
2-T-TFL(Q)-TO(II)-F-2



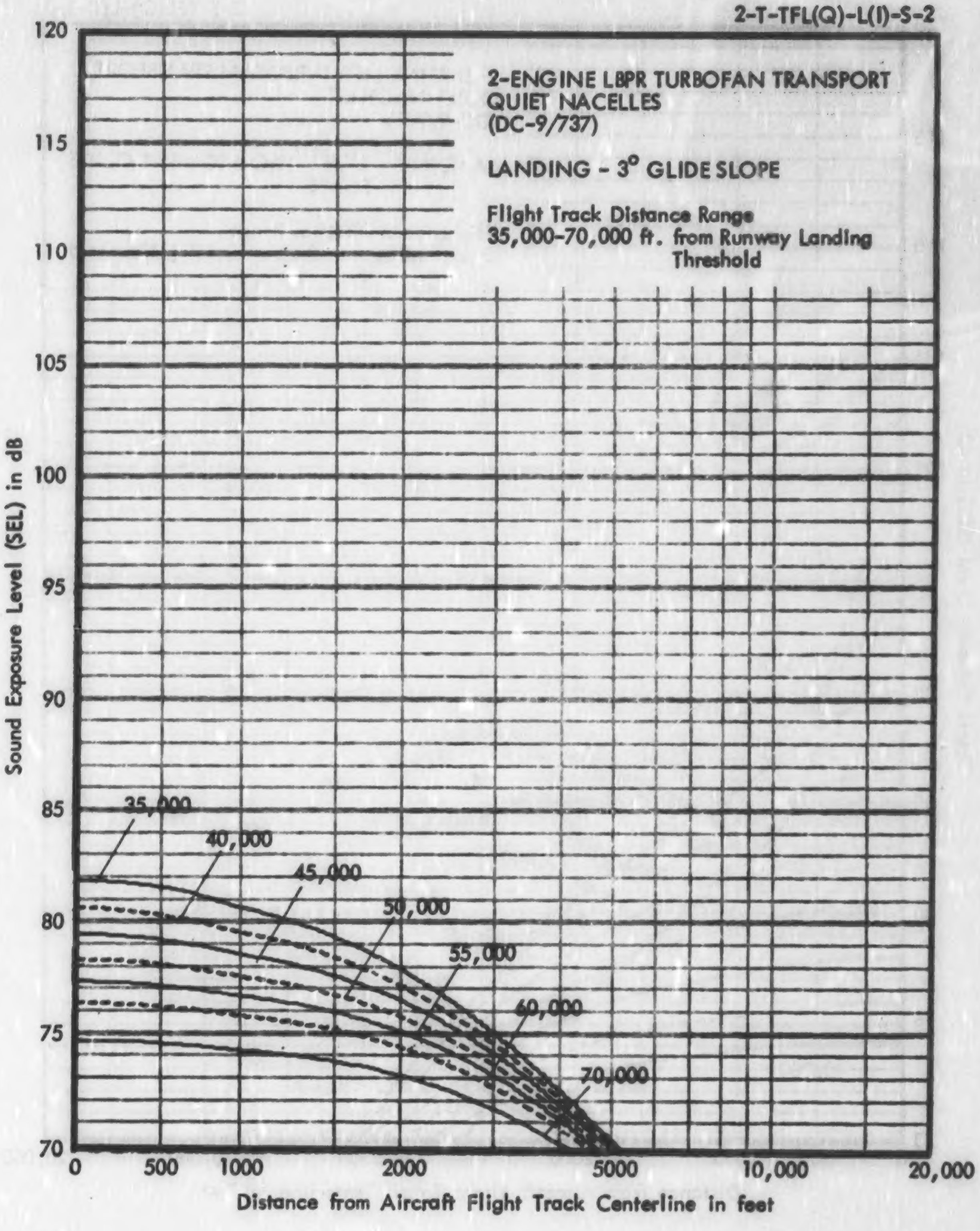
2-T-TFL(Q)-TO(II)-F-3



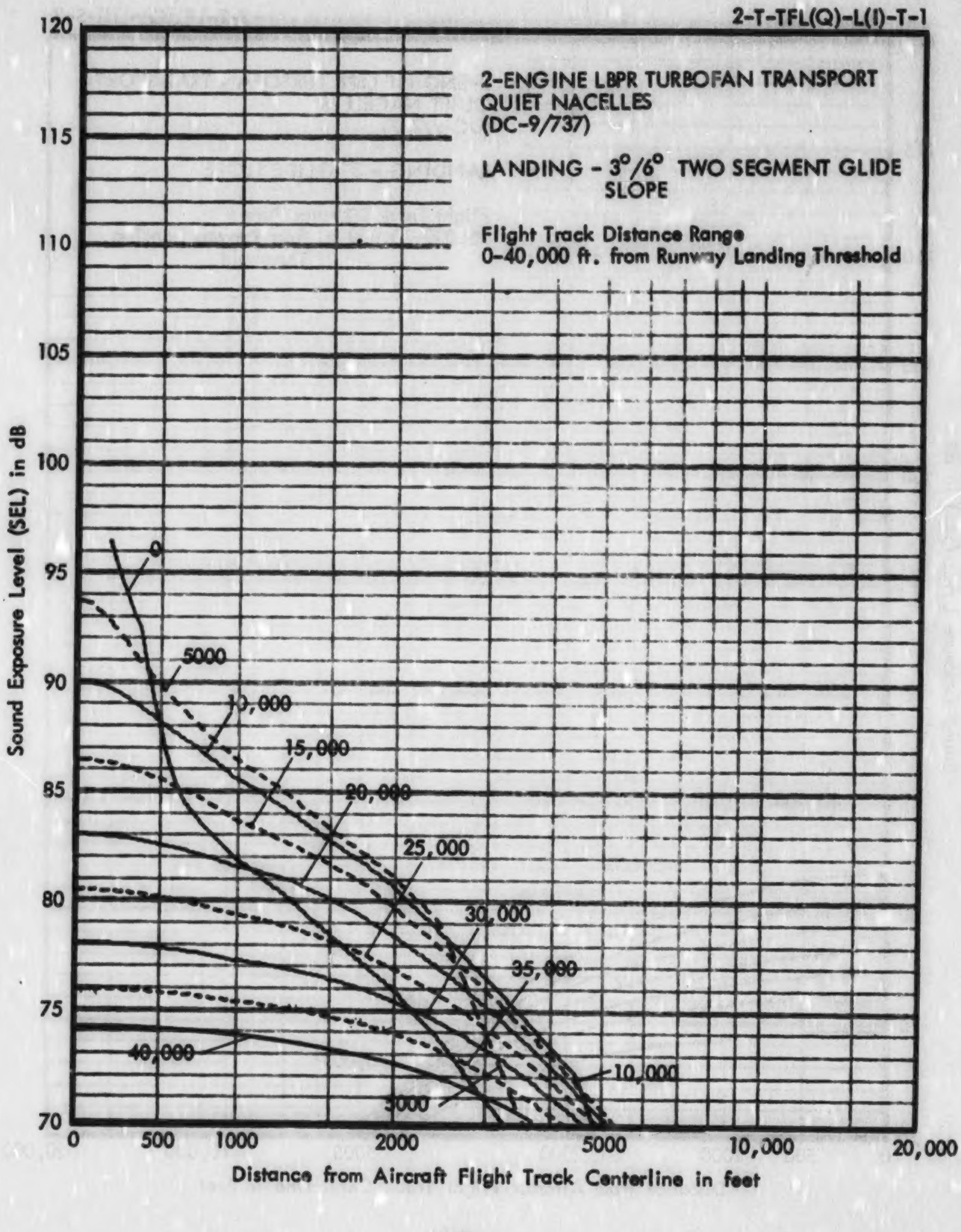
2-T-TFL(Q)-L(I)-S-1

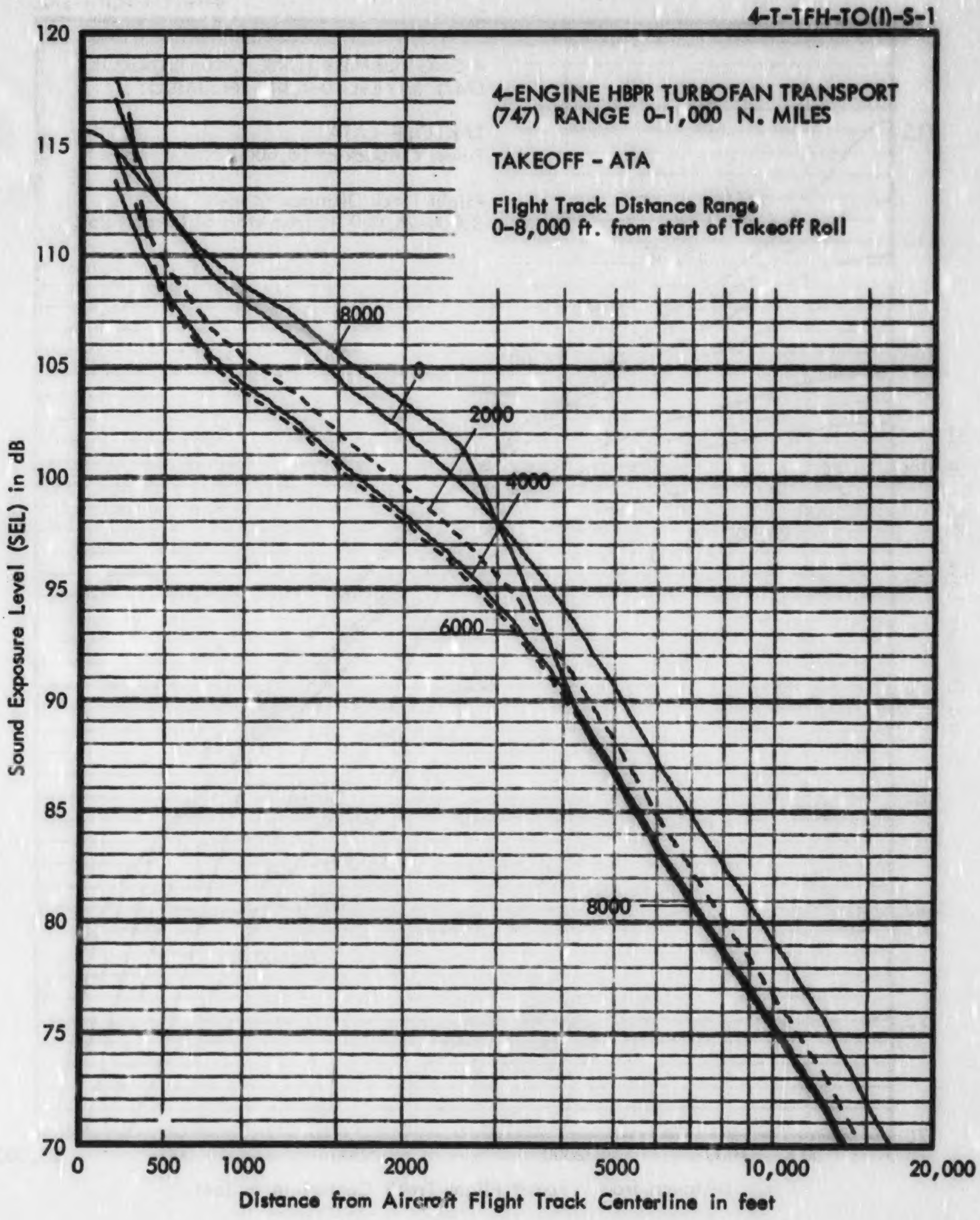

2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
5,000
10,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

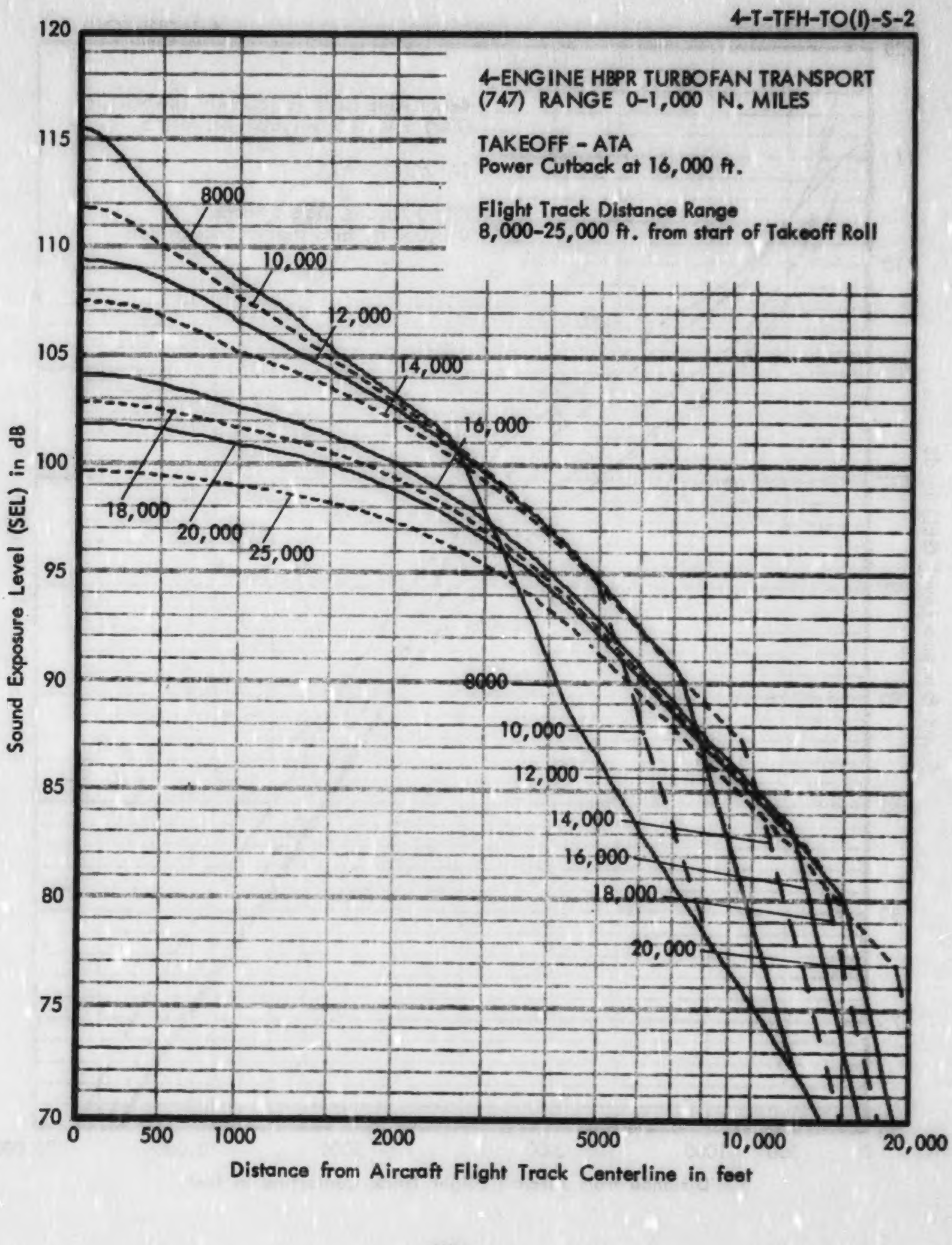
2-T-TFL(Q)-L(I)-S-2


2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
35,000-70,000 ft. from Runway Landing Threshold
35,000
40,000
45,000
50,000
55,000
60,000
70,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

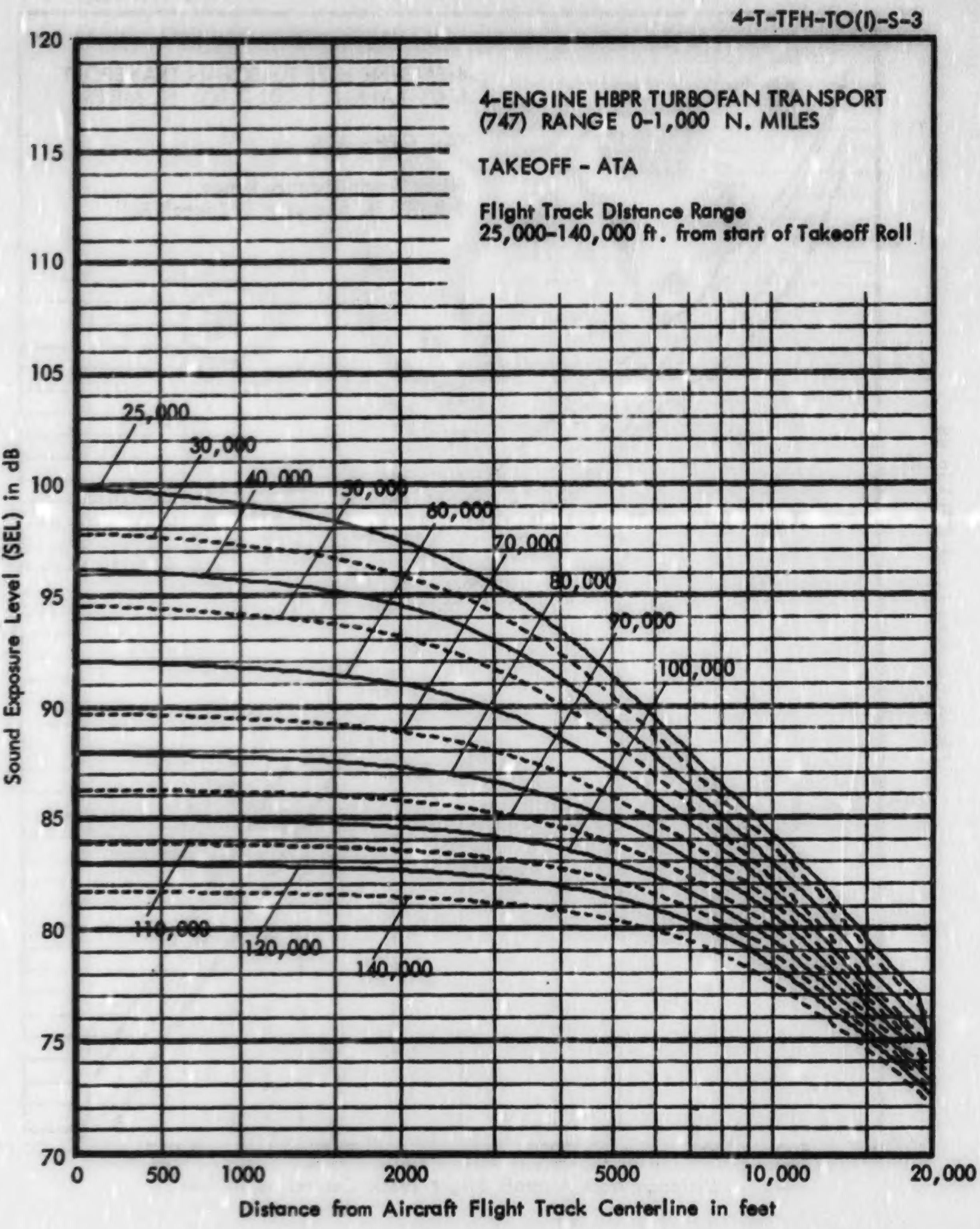
2-T-TFL(Q)-L(I)-T-1


2-ENGINE LBPR TURBOFAN TRANSPORT
QUIET NACELLES
(DC-9/737)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range
0-40,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
10,000
3000

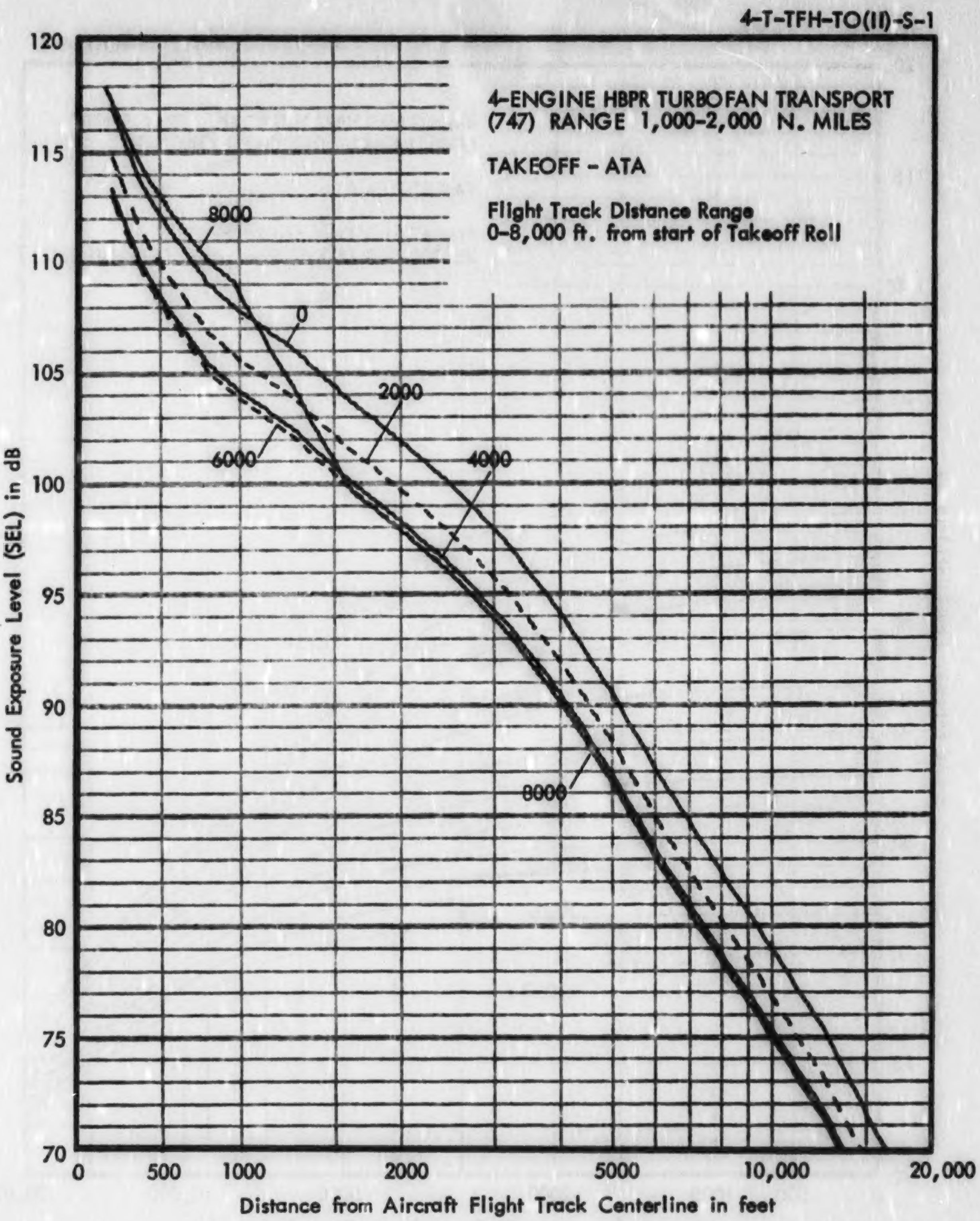

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
8000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

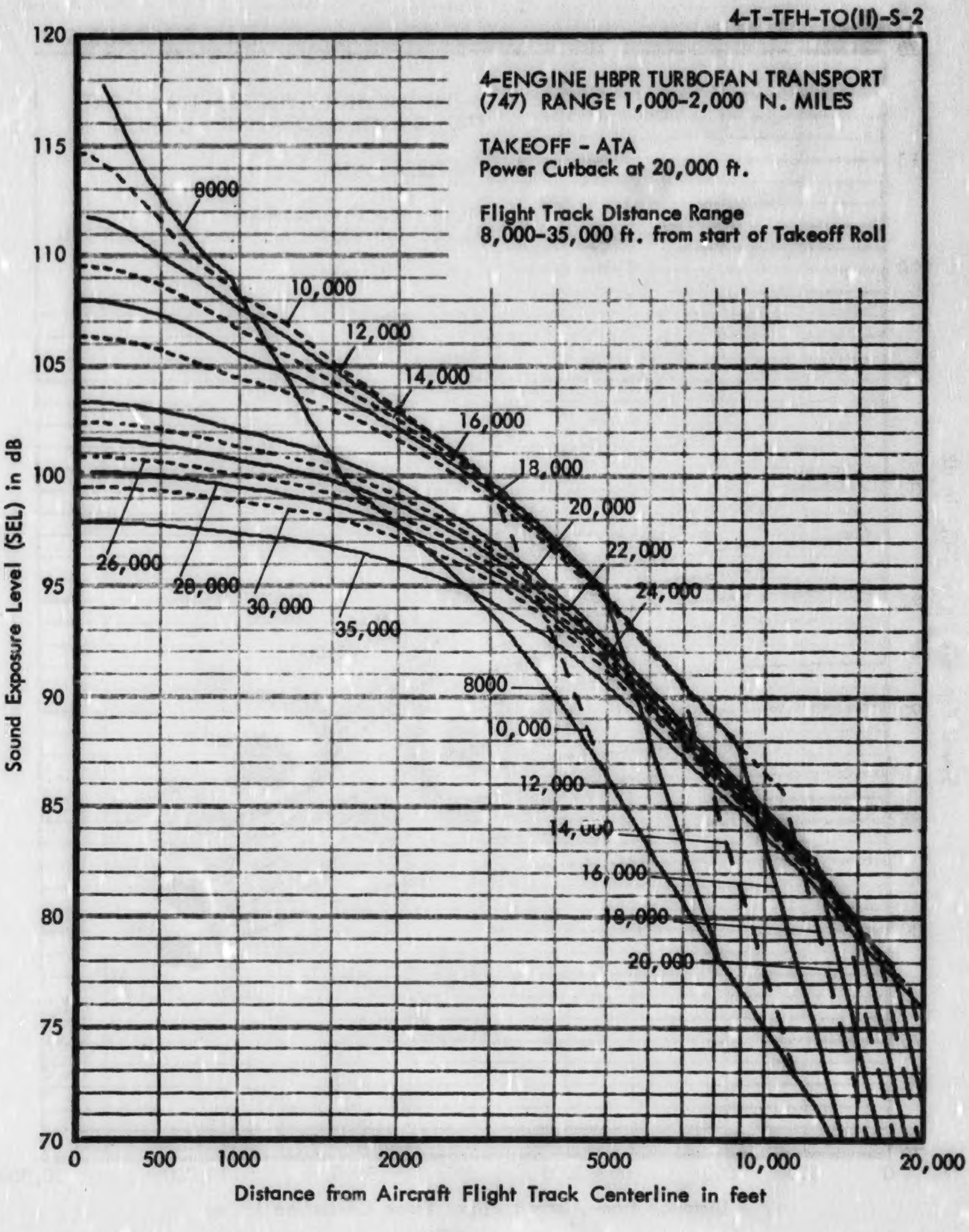

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - ATA
Power Cutback at 16,000 ft.
Flight Track Distance Range
8,000-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
8000
10,000
12,000
14,000
16,000
18,000
20,000

4-T-TFH-TO(I)-S-3

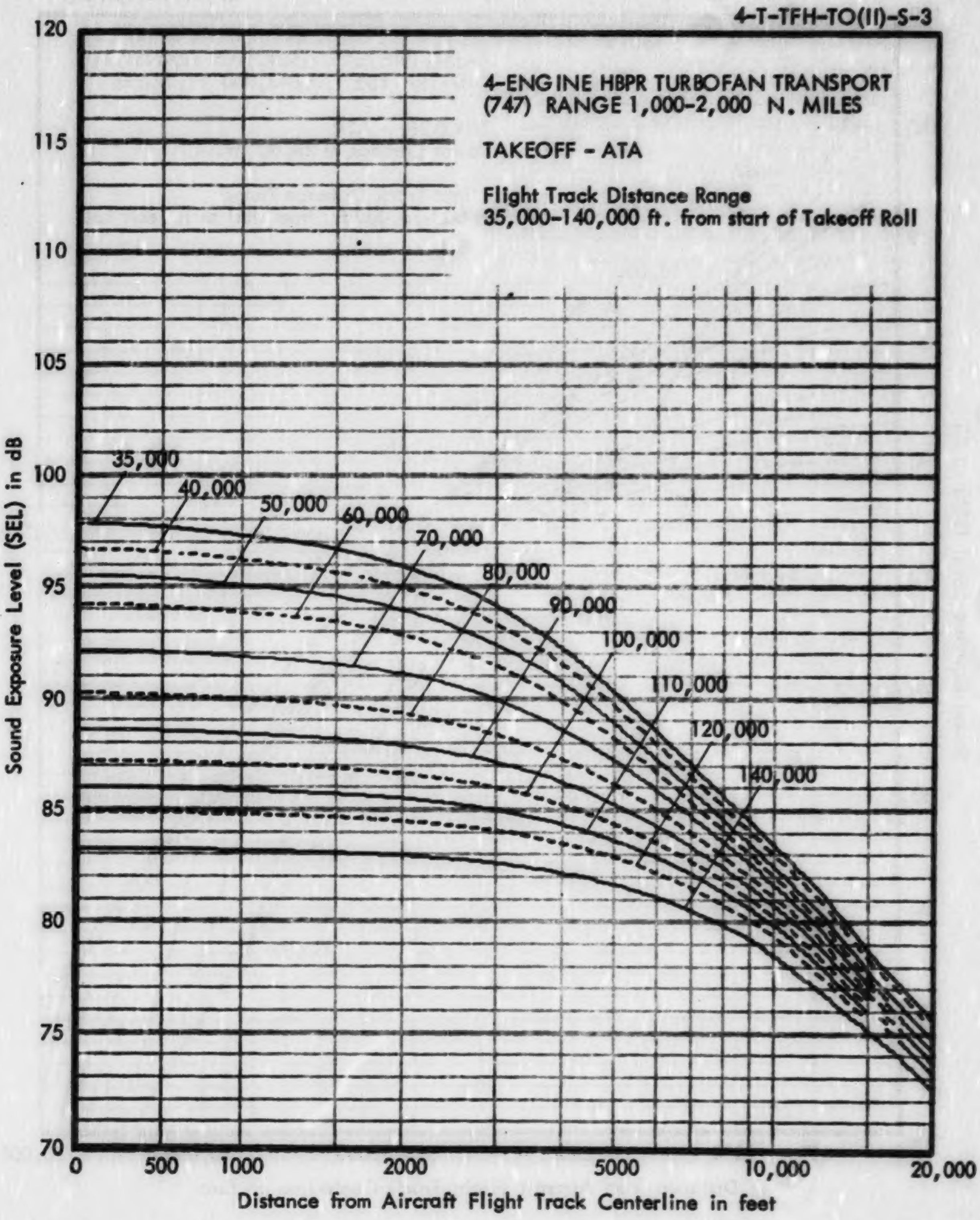

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
25,000-140,000 ft. from start of Takeoff Roll
25,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
140,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

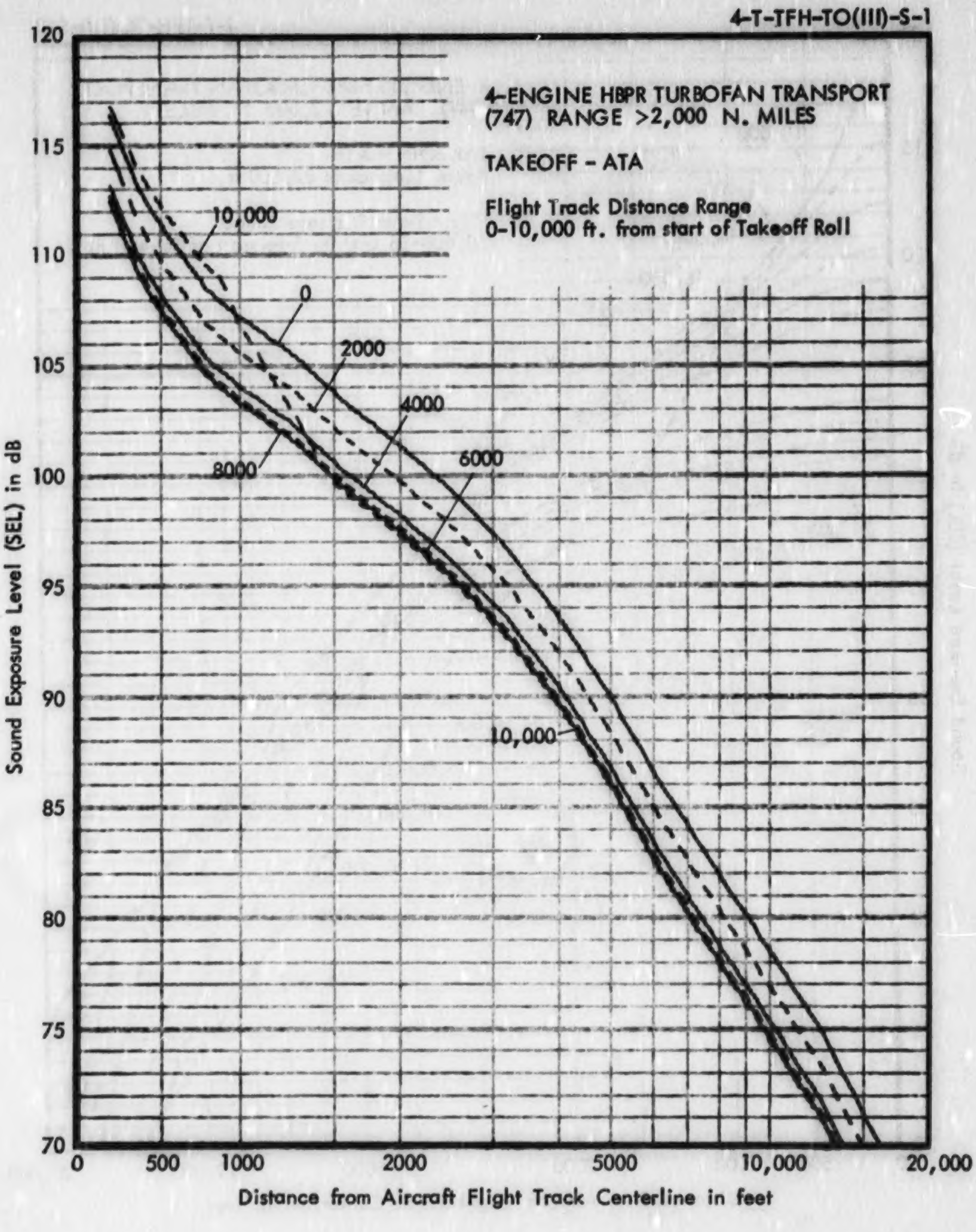
4-T-TFH-TO(II)-S-1



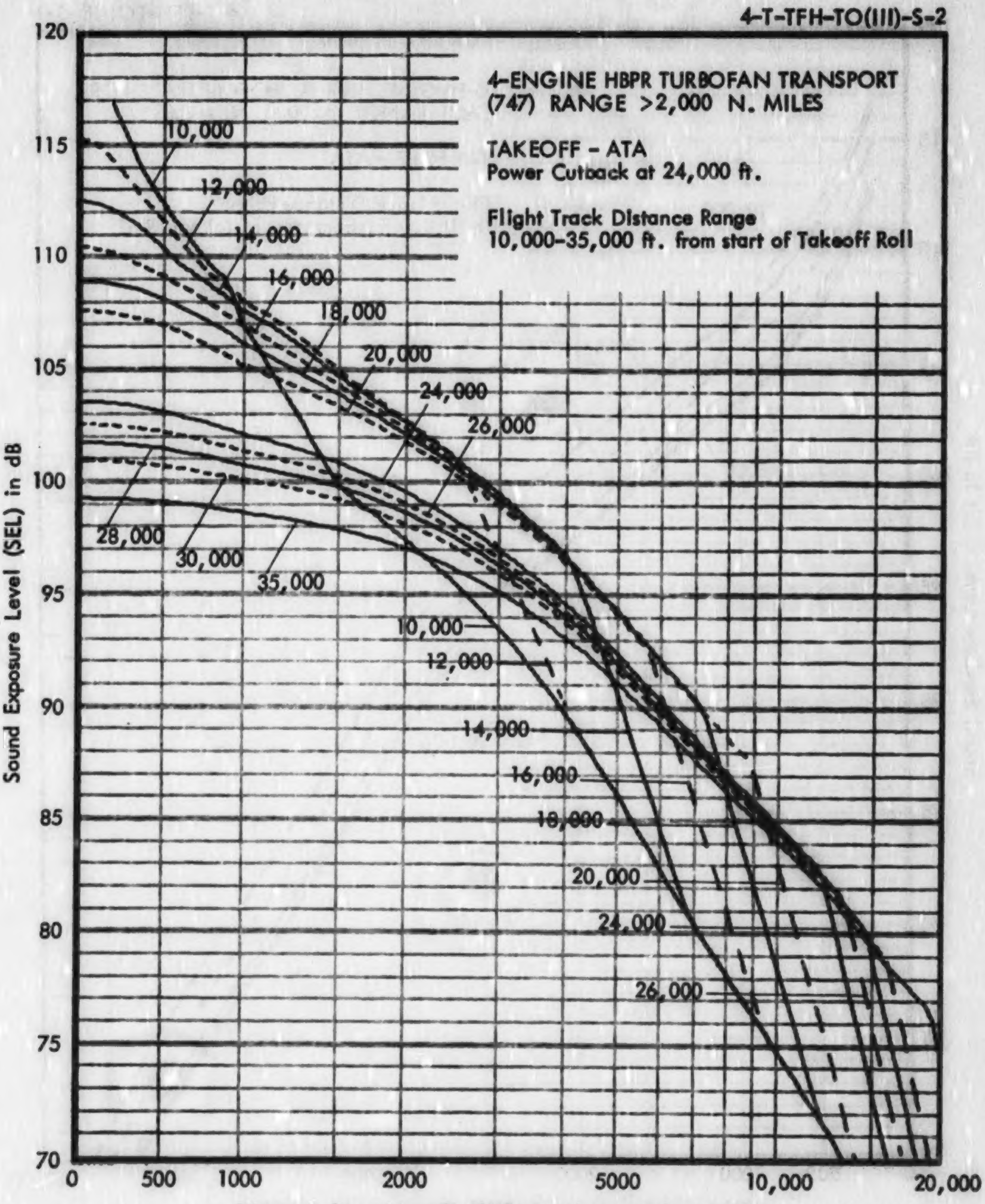

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - ATA
Power Cutback at 20,000 ft.
Flight Track Distance Range
8,000-35,000 ft. from start of Takeoff Roll
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
35,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

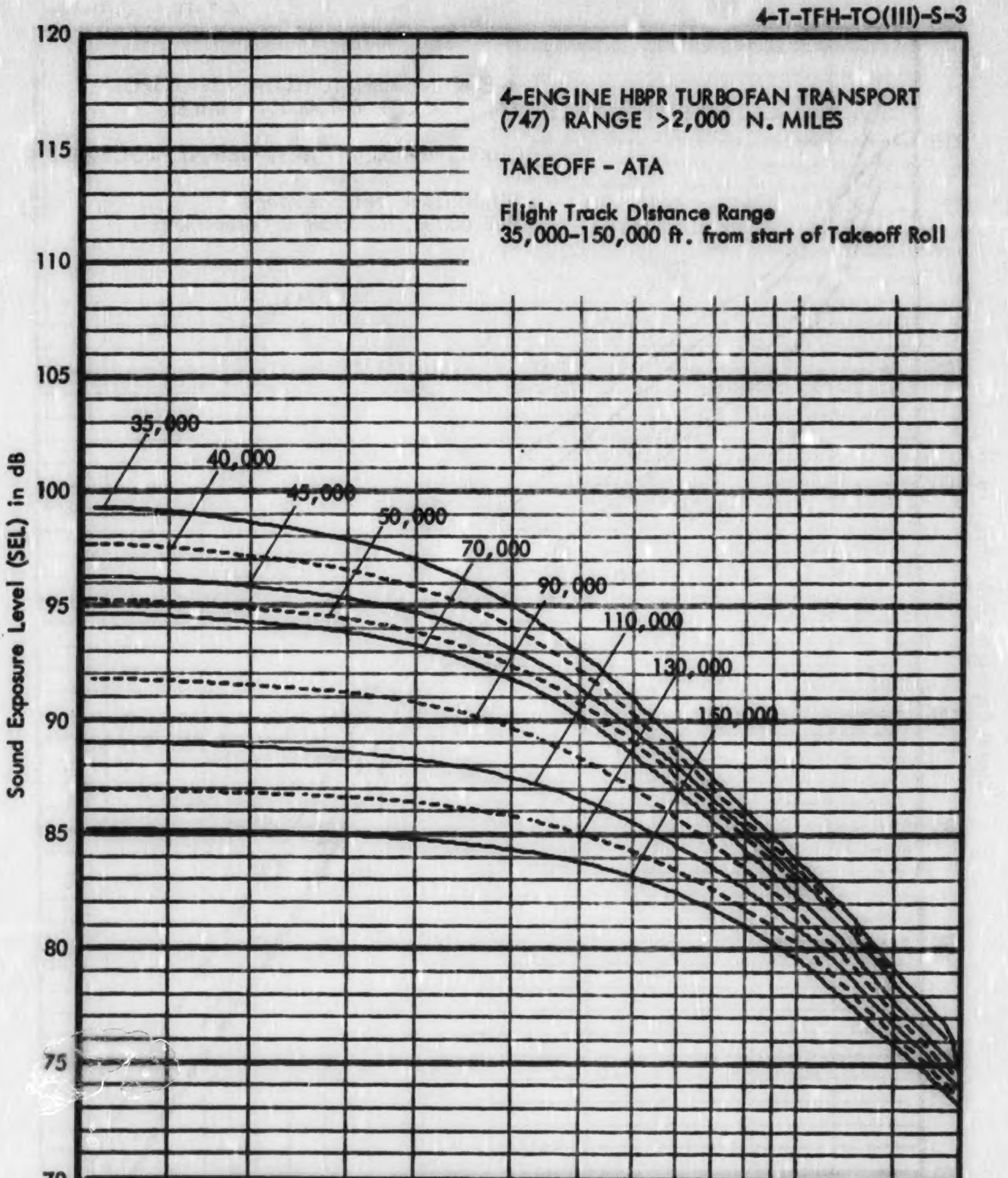
4-T-TFH-TO(II)-S-3

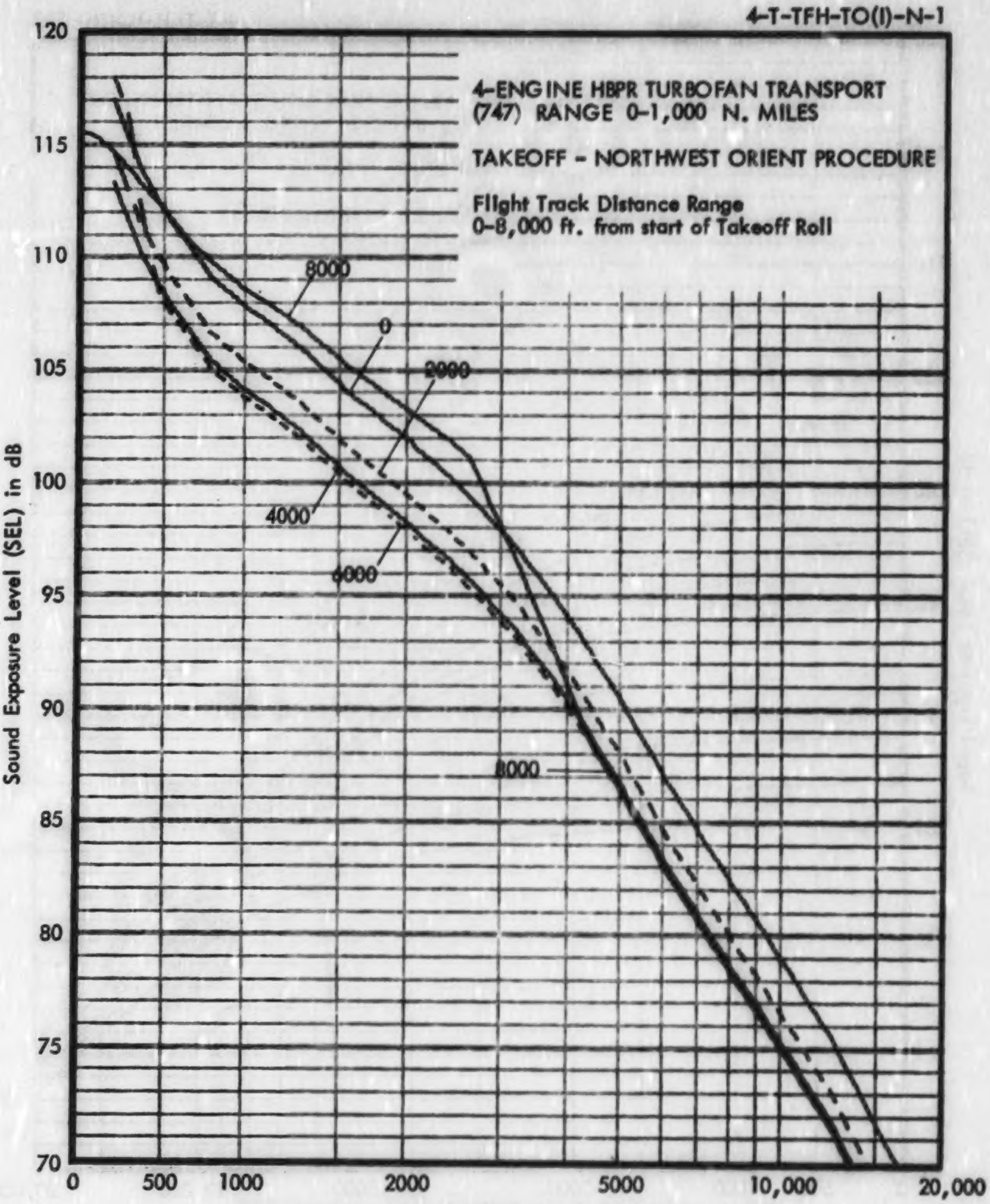



4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE >2,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
10,000
0
2000
4000
8000
6000
10,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

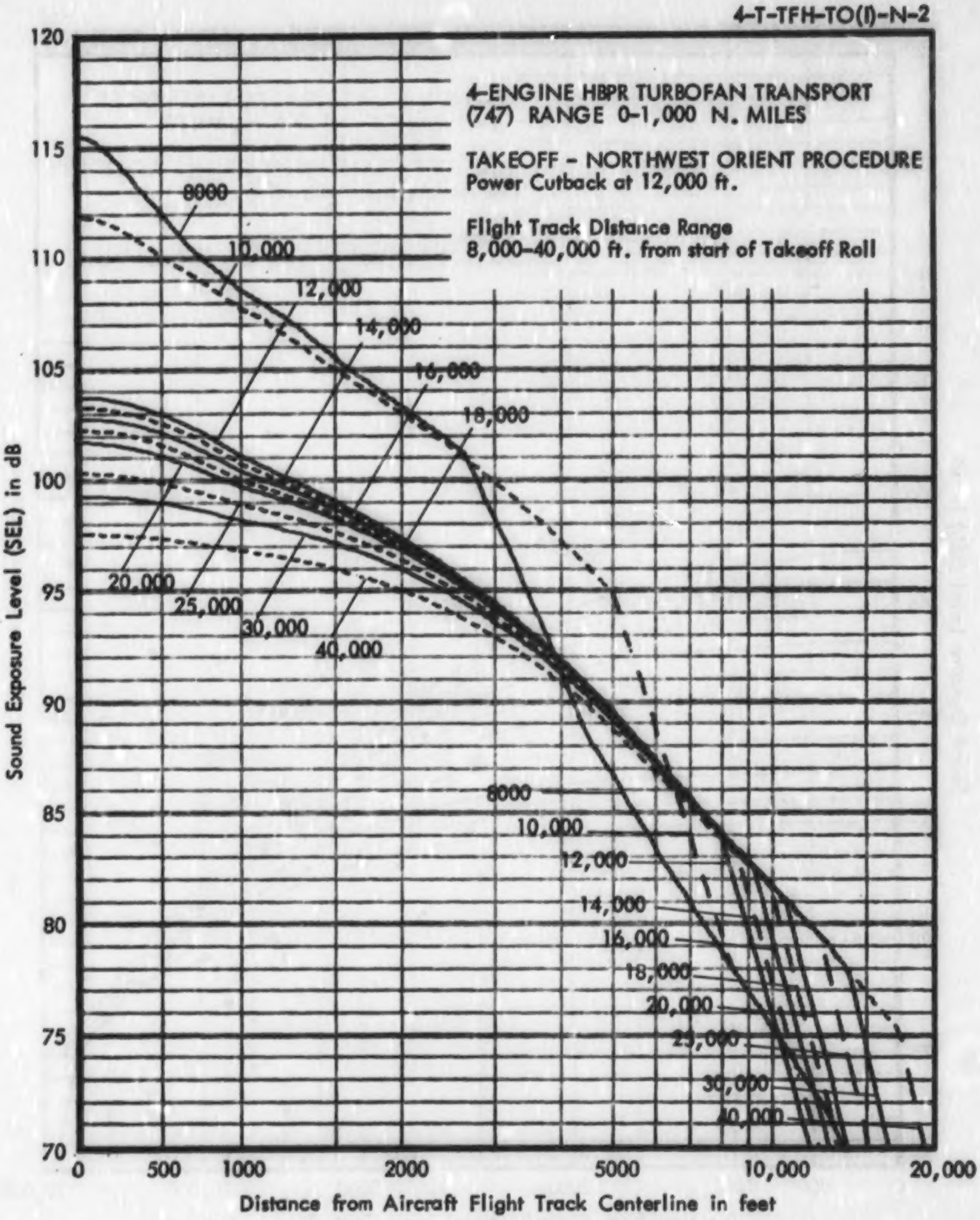
4-T-TFH-TO(III)-S-2



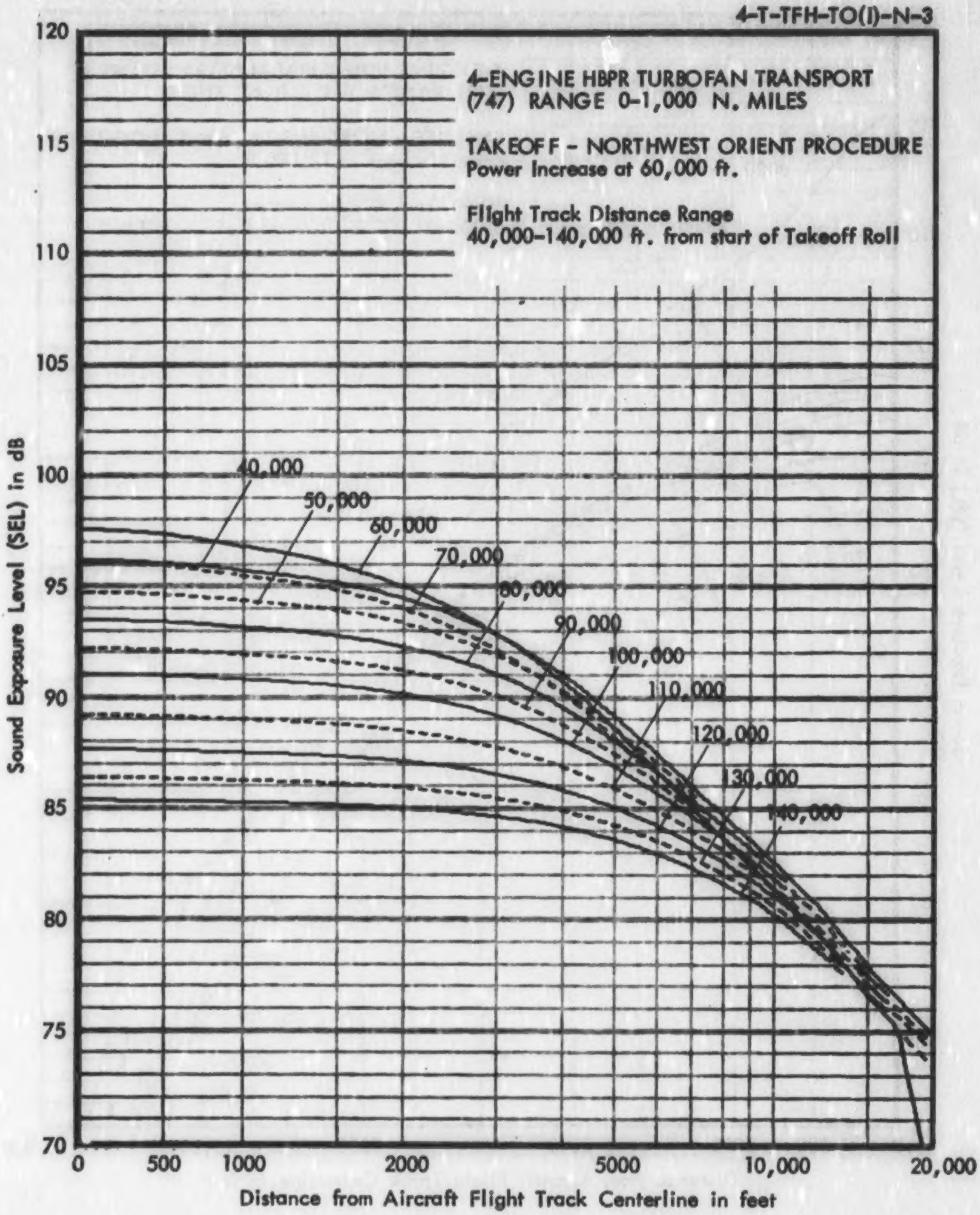

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE >2,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
35,000-150,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
50,000
70,000
90,000
110,000
130,000
150,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

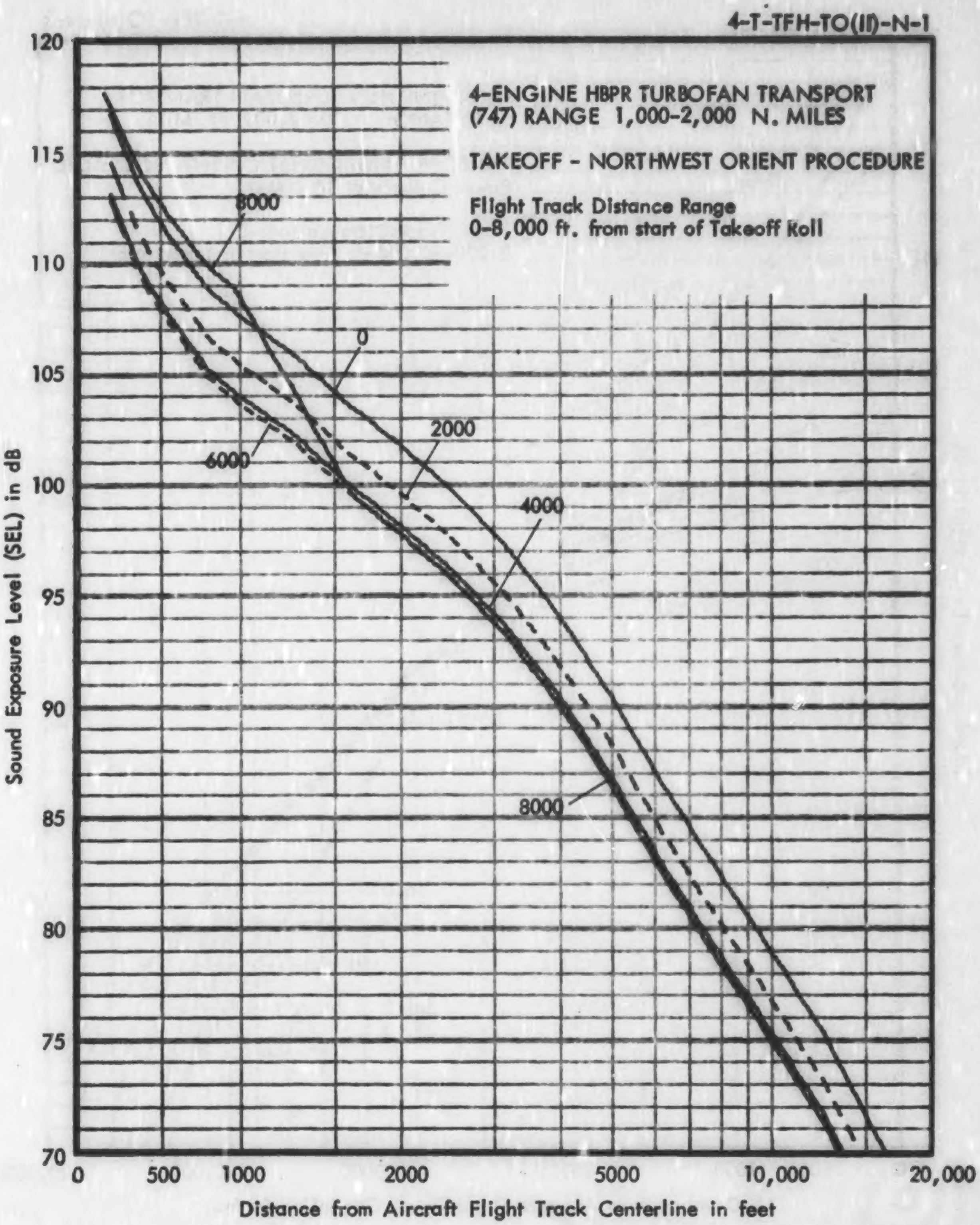

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
8000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

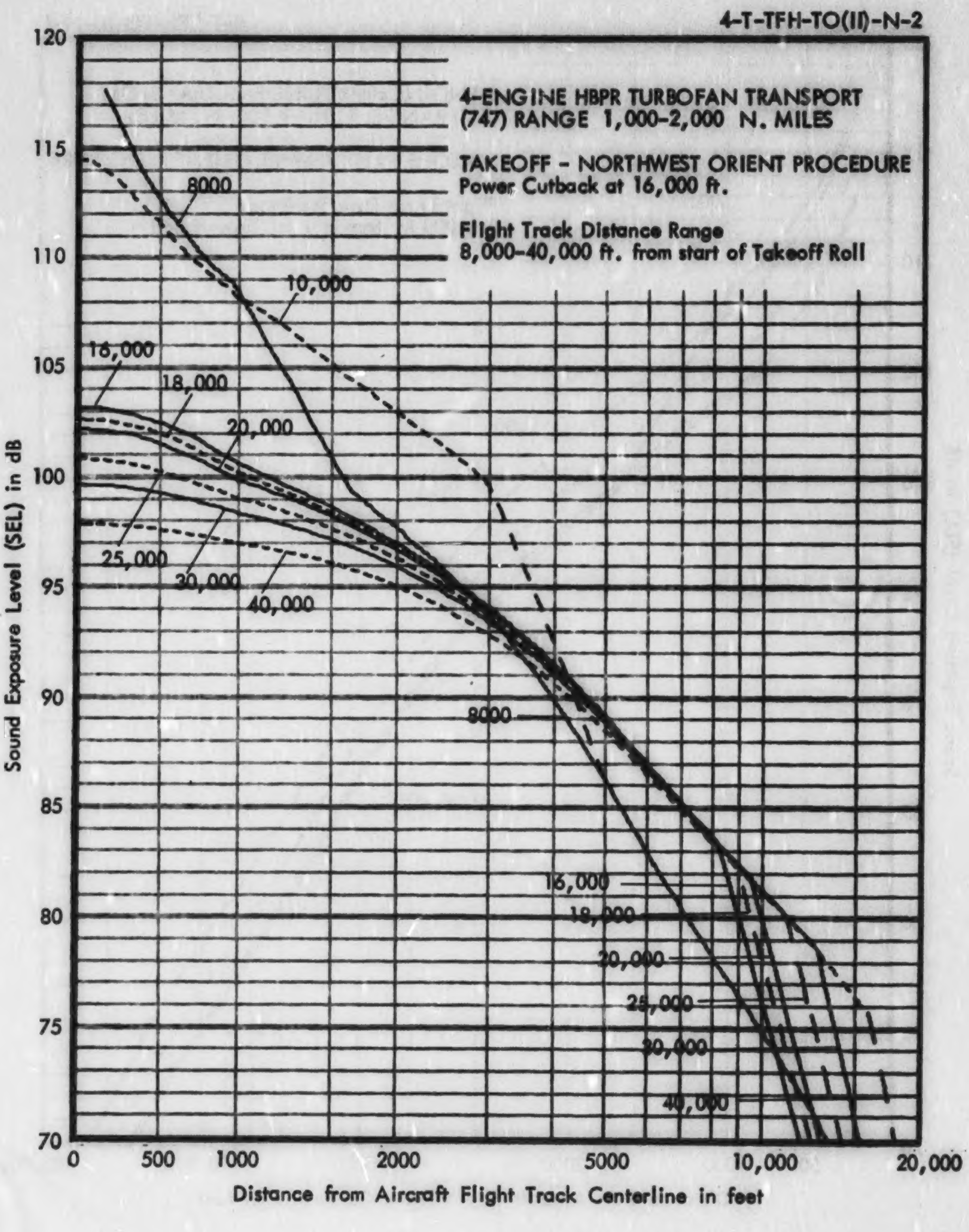
4-T-TFH-TO(I)-N-2


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 12,000 ft.
Flight Track Distance Range
8,000-40,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
40,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
40,000

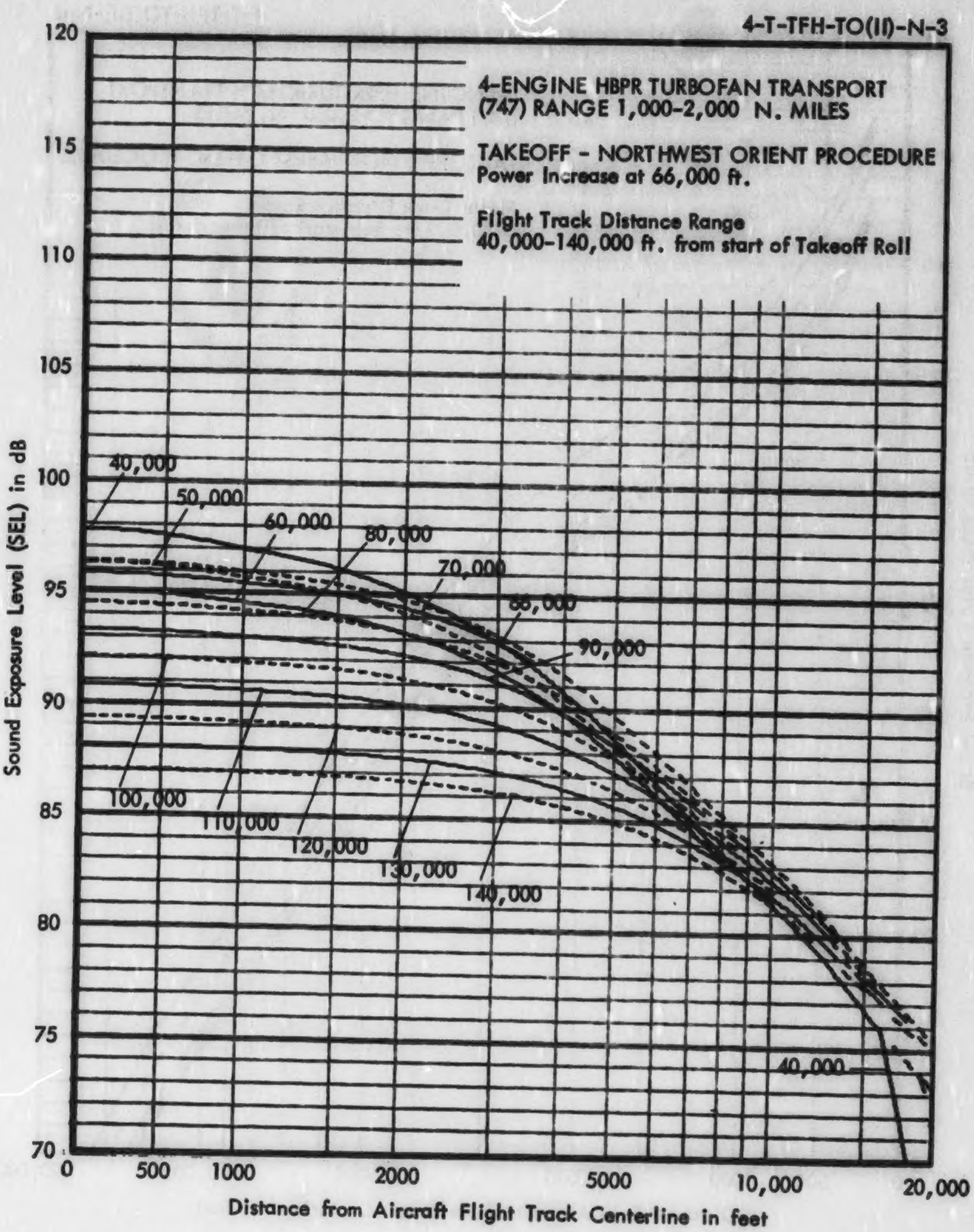
4-T-TFH-TO(I)-N-3


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 60,000 ft.
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
130,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
6000
4000
8000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 16,000 ft.
Flight Track Distance Range
8,000-40,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
8000
10,000
16,000
18,000
20,000
25,000
30,000
40,000
8000
16,000
18,000
20,000
25,000
30,000
40,000

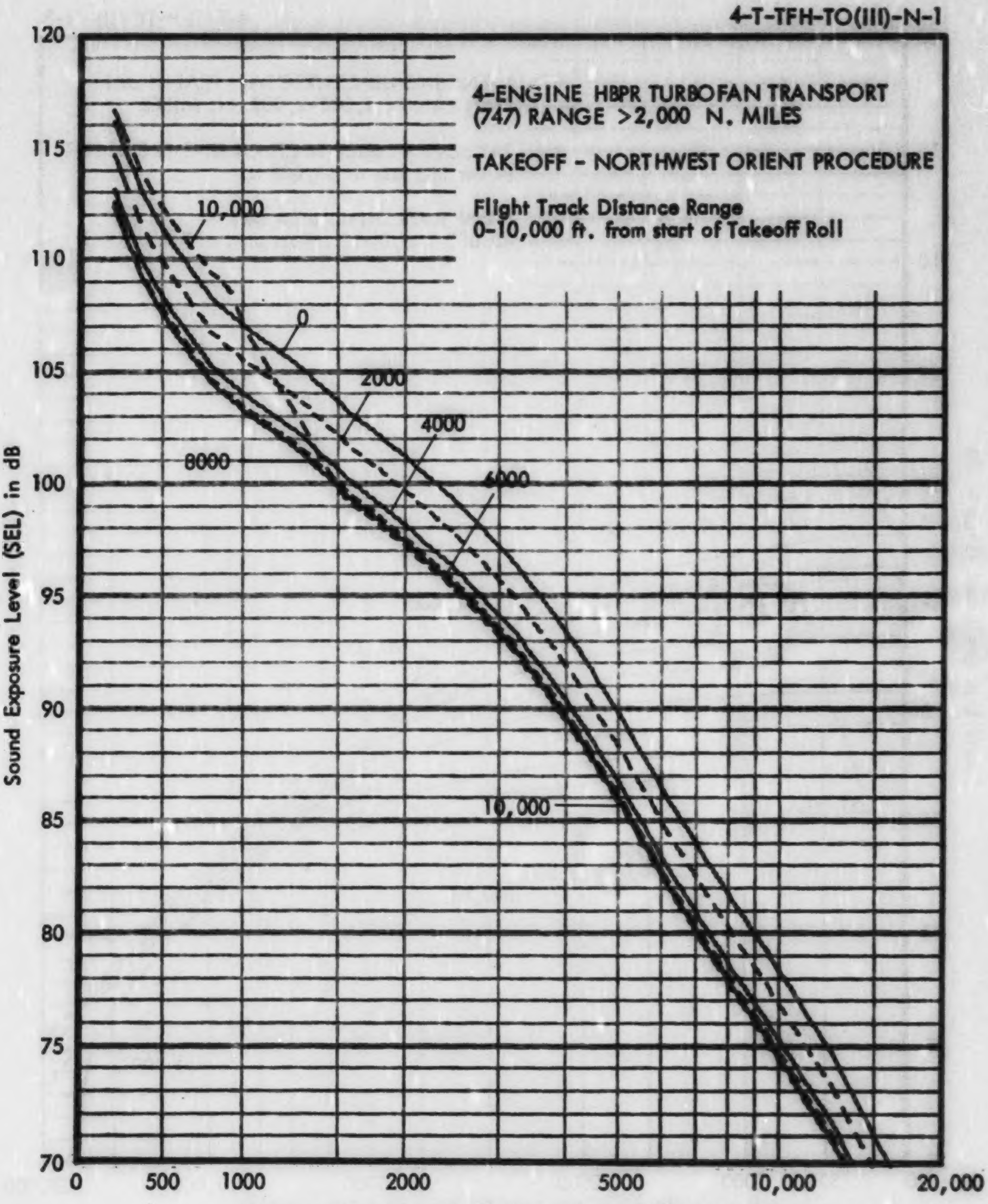
4-T-TFH-TO(II)-N-3

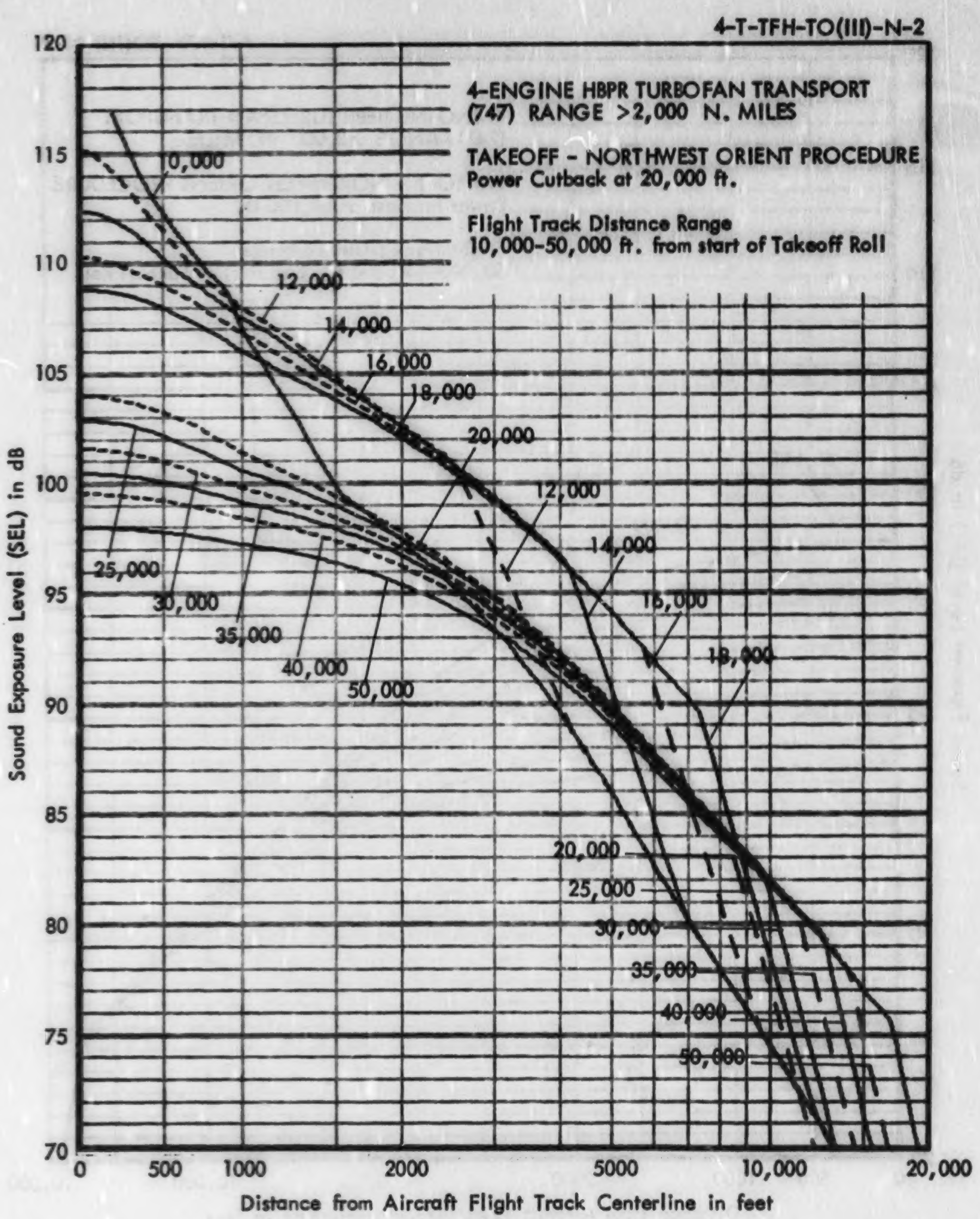


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 1,000-2,000 N. MILES

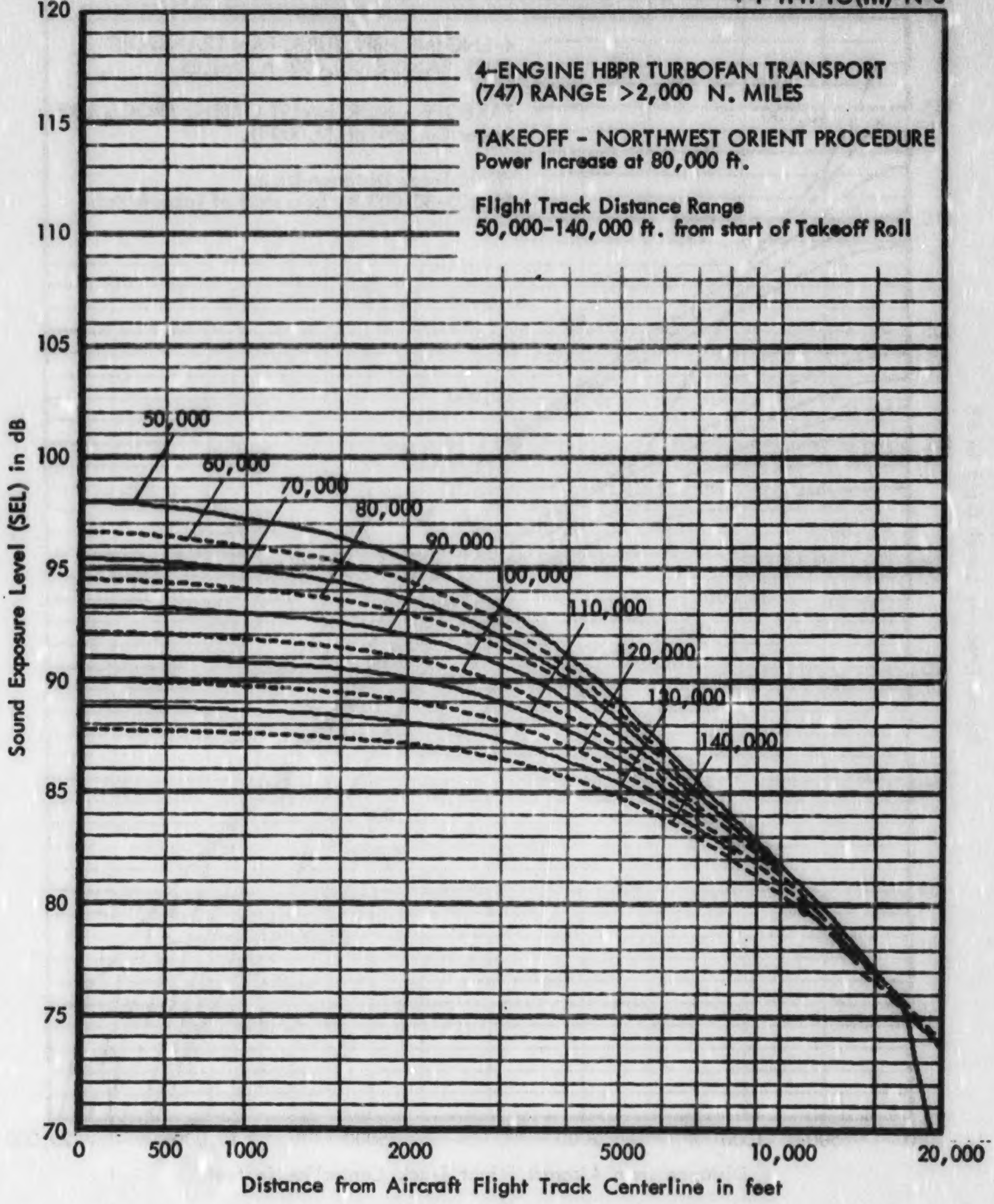
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 66,000 ft.

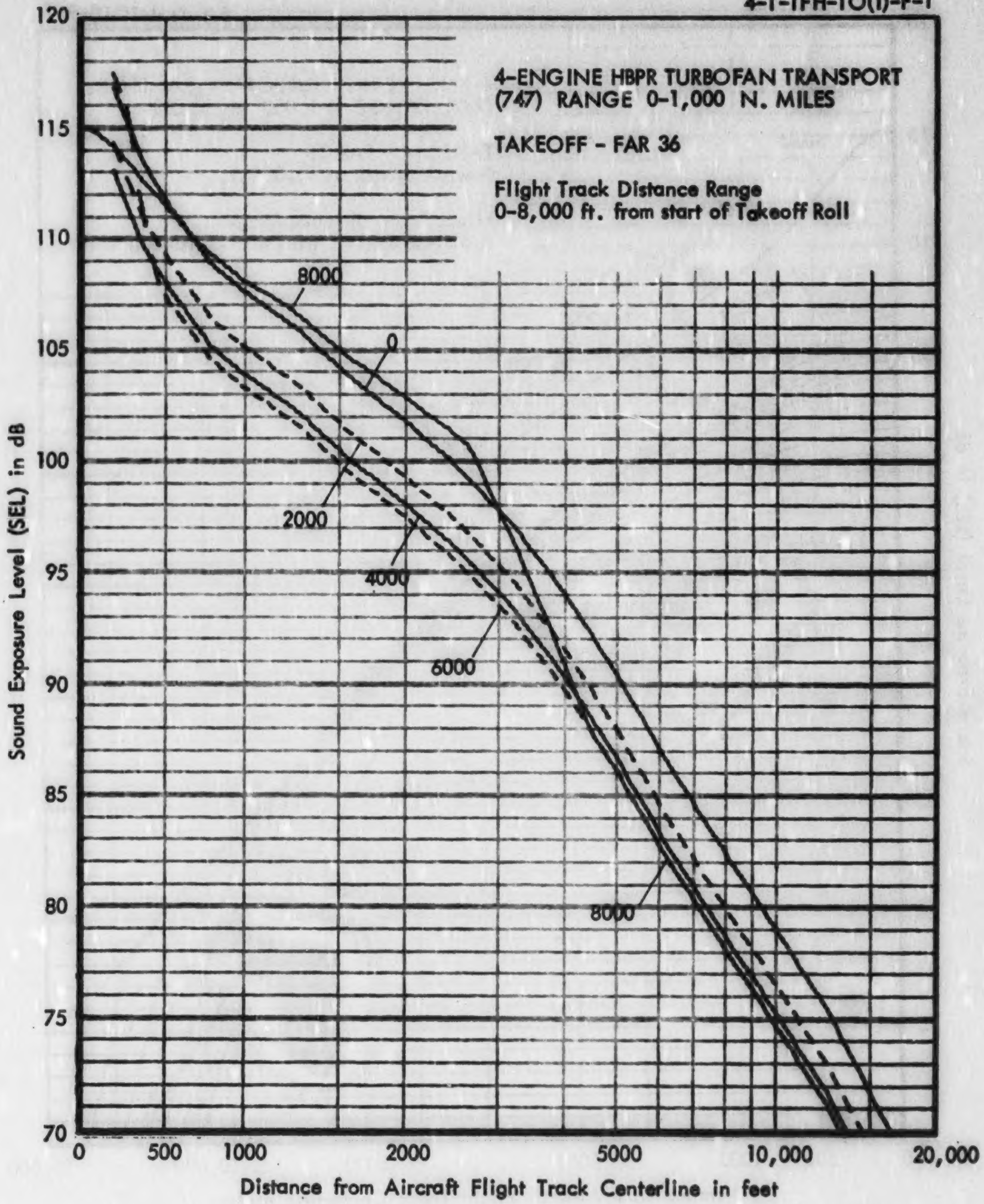
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE >2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
10,000
0
2000
4000
8000
6000
10,000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

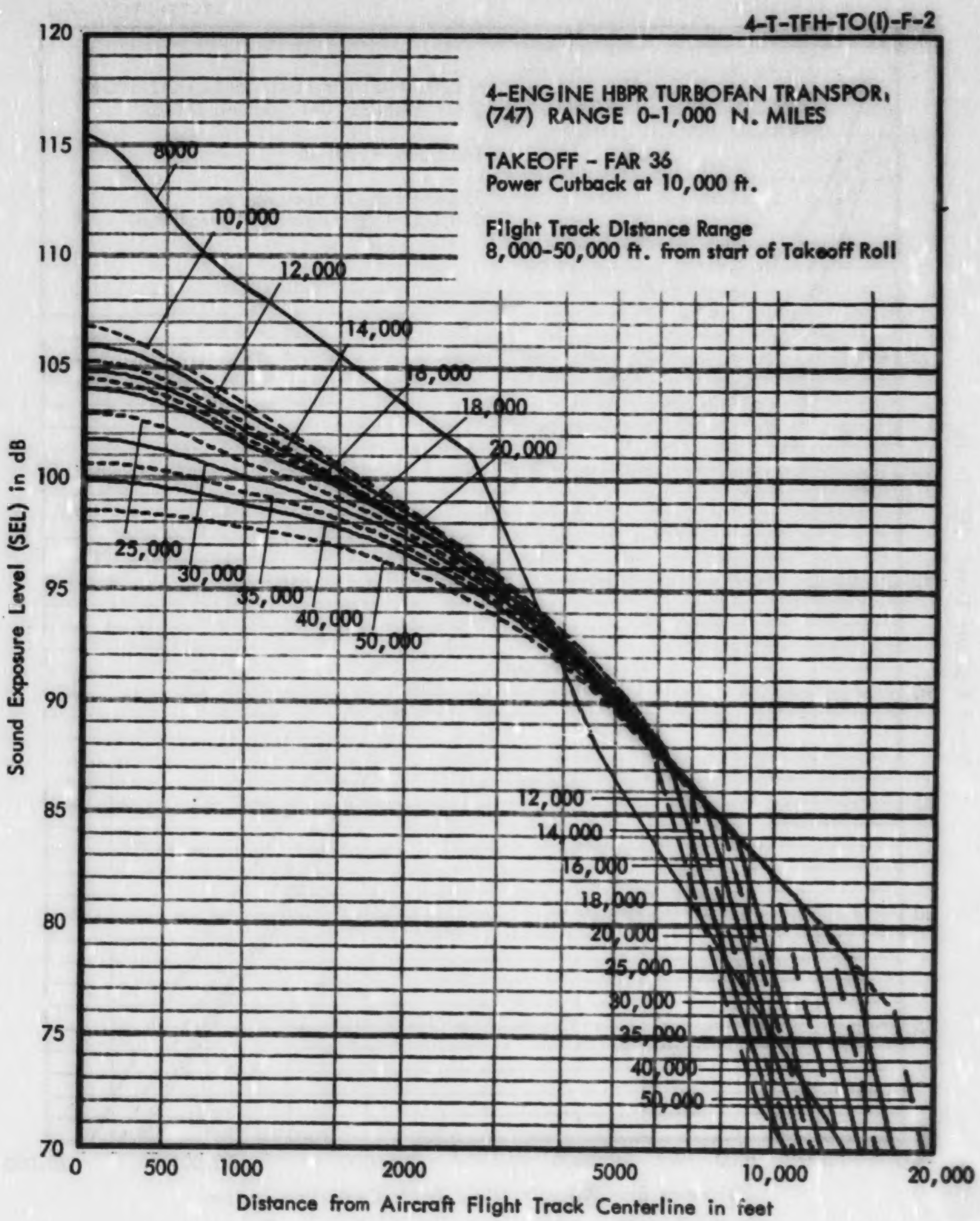

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE >2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 20,000 ft.
Flight Track Distance Range
10,000-50,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
10,000
12,000
14,000
16,000
18,000
20,000
12,000
14,000
16,000
18,000
25,000
30,000
35,000
40,000
50,000
20,000
25,000
30,000
35,000
40,000
50,000

4-T-TFH-TO(III)-N-3

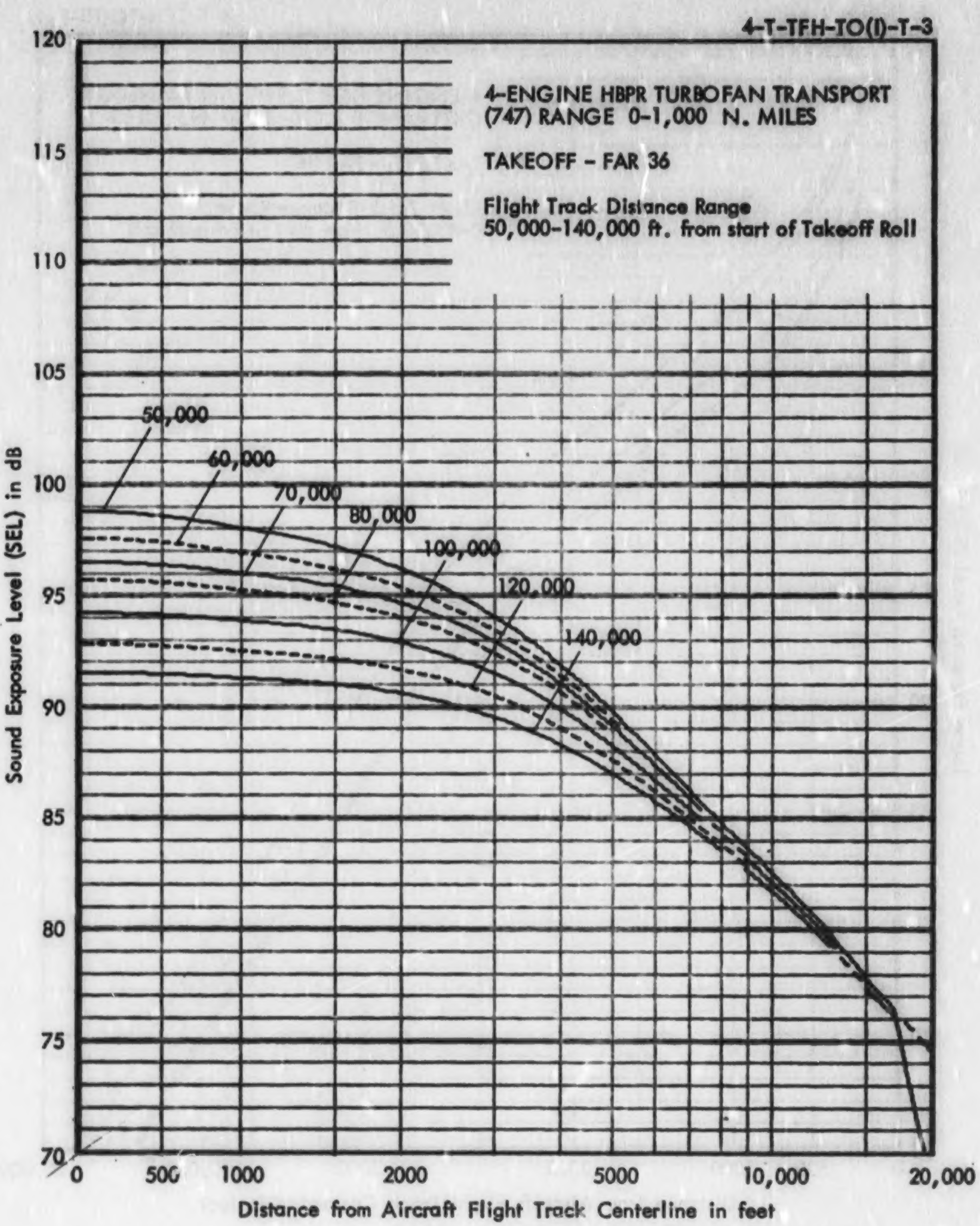


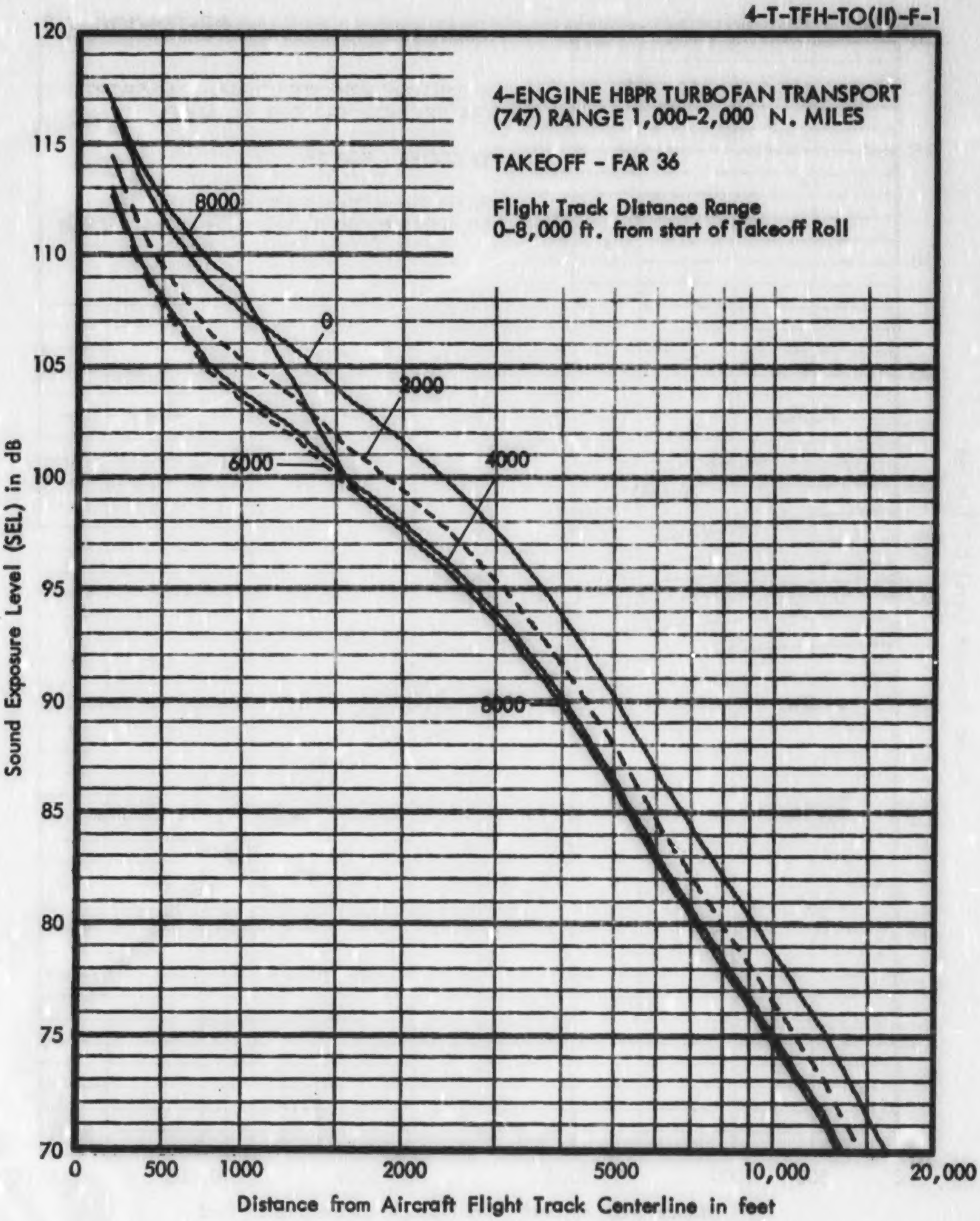

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
4000
6000
8000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

4-T-TFH-TO(I)-F-2

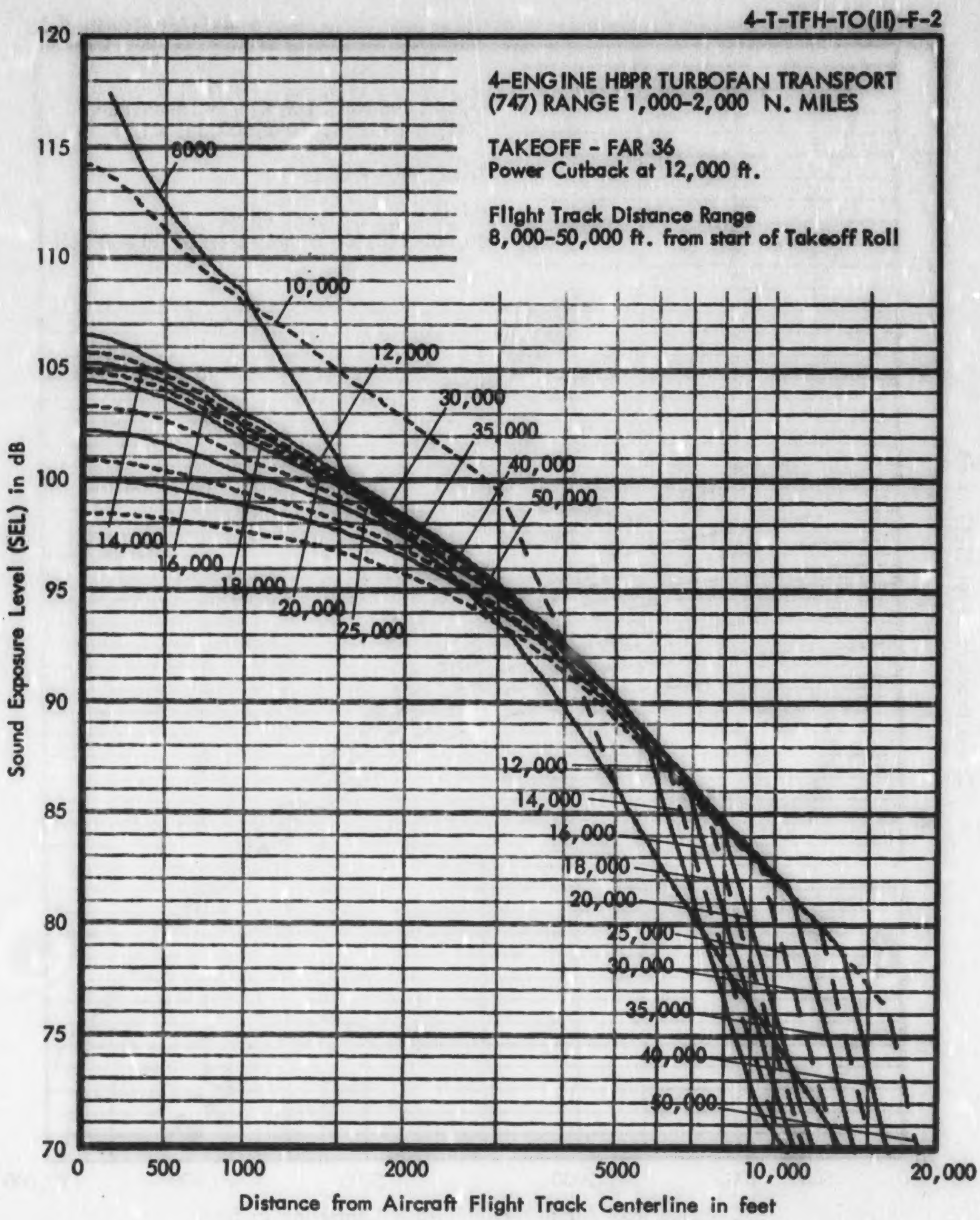

4-ENGINE HBPR TURBOFAN TRANSPOR,
(747) RANGE 0-1,000 N. MILES
TAKEOFF - FAR 36
Power Cutback at 10,000 ft.
Flight Track Distance Range
8,000-50,000 ft. from start of Takeoff Roll
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

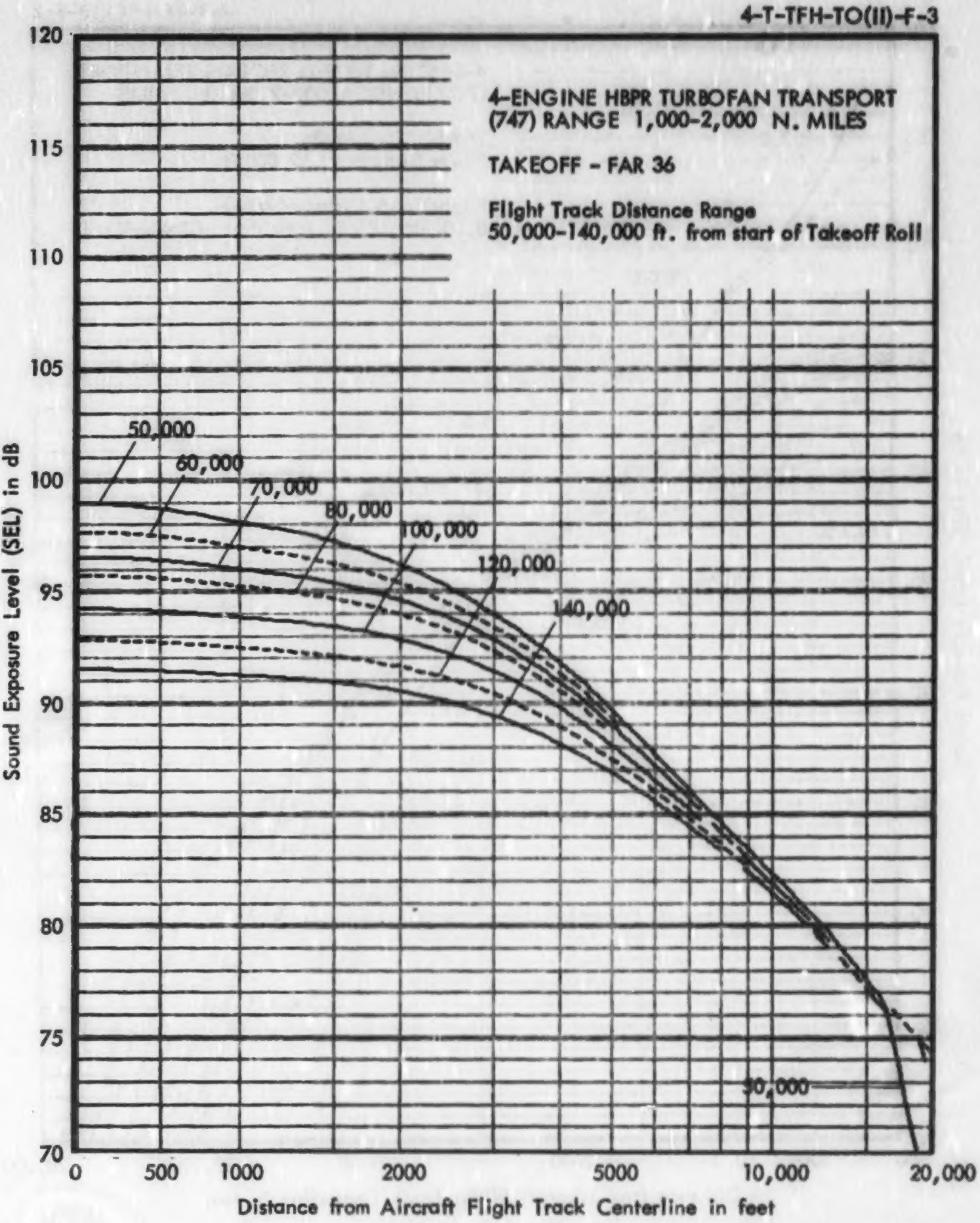
4-T-TFH-TO(I)-T-3

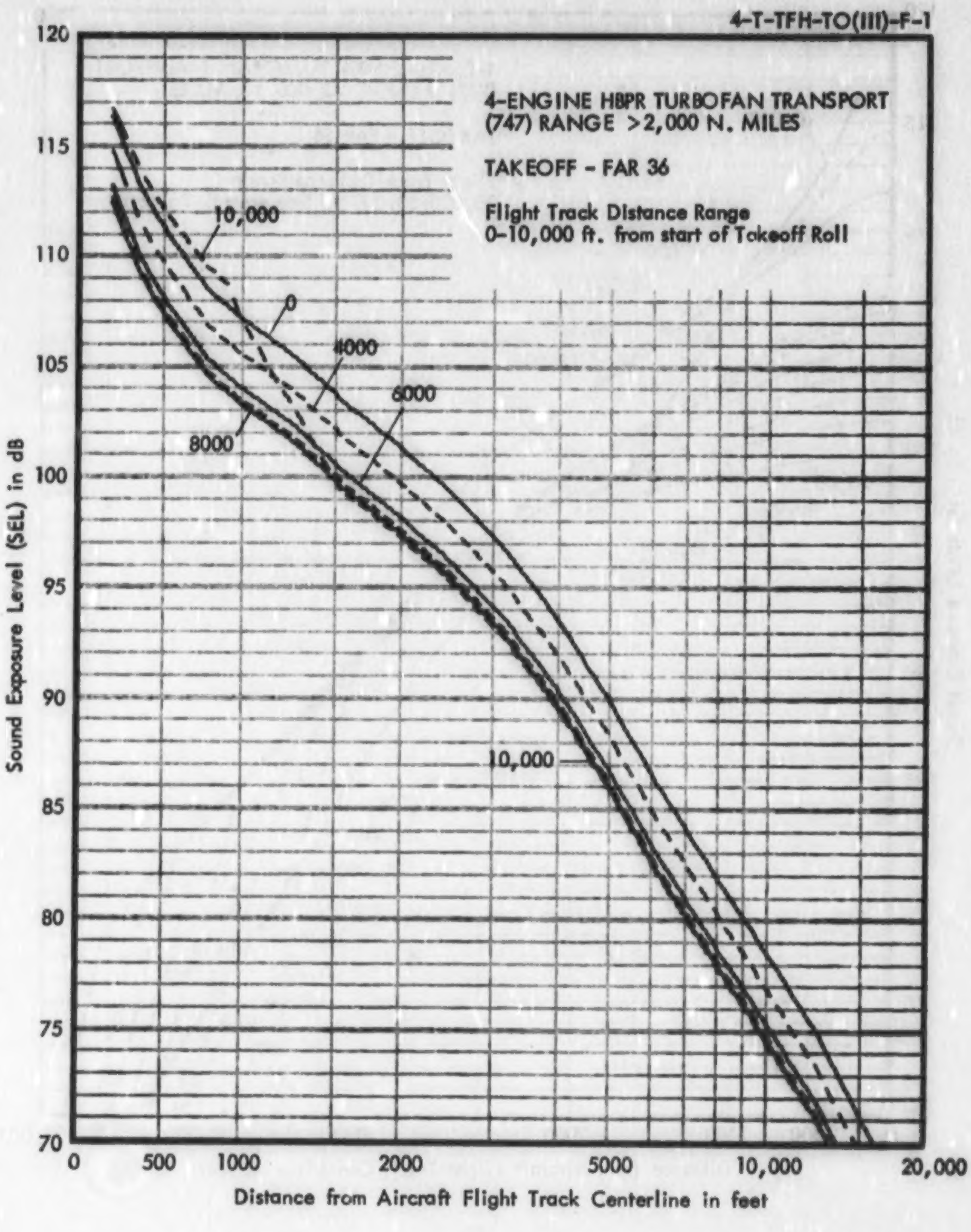

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 0-1,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
50,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
50,000
60,000
70,000
80,000
100,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

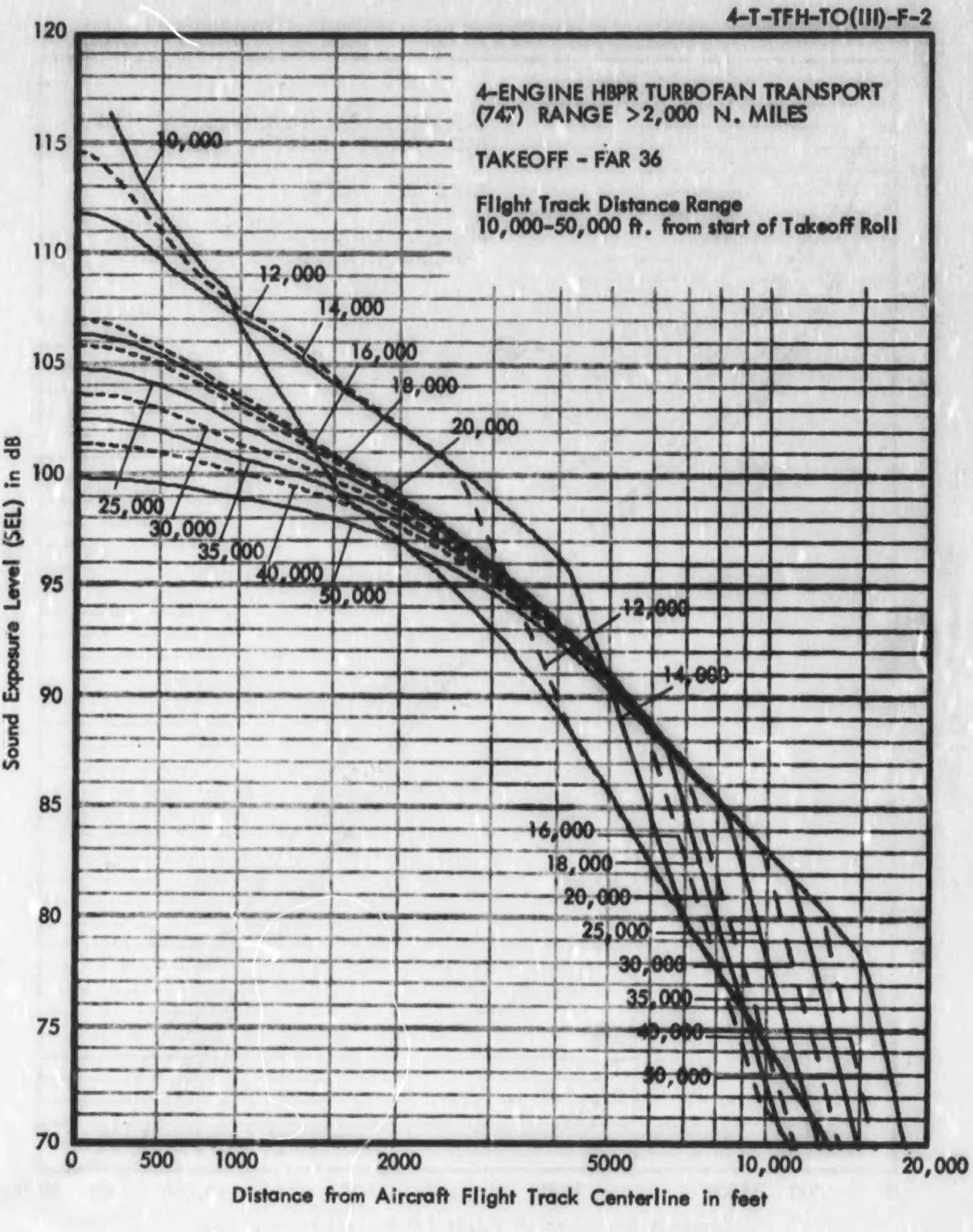

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8000
0
2000
6000
4000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

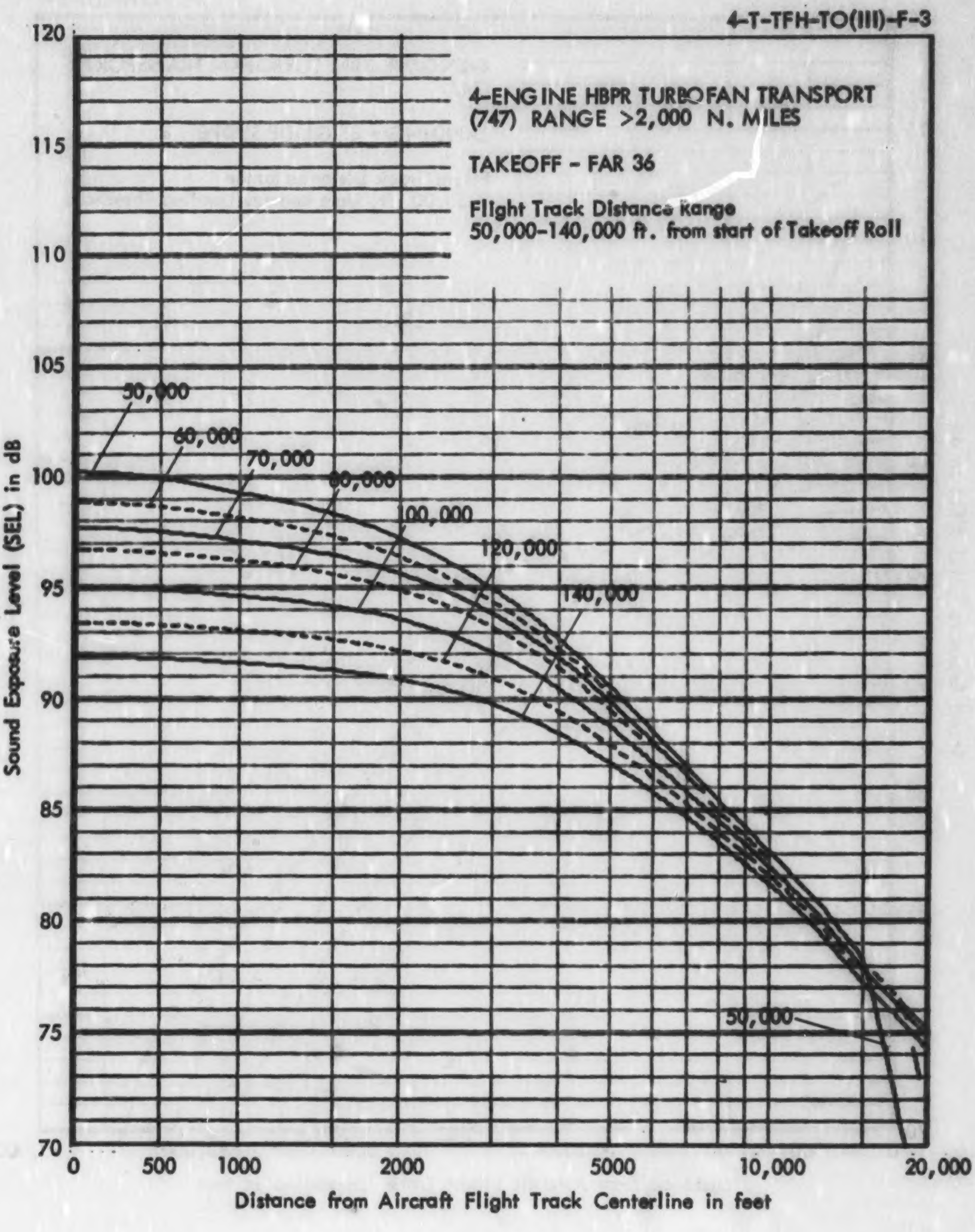
4-T-TFH-TO(II)-F-2



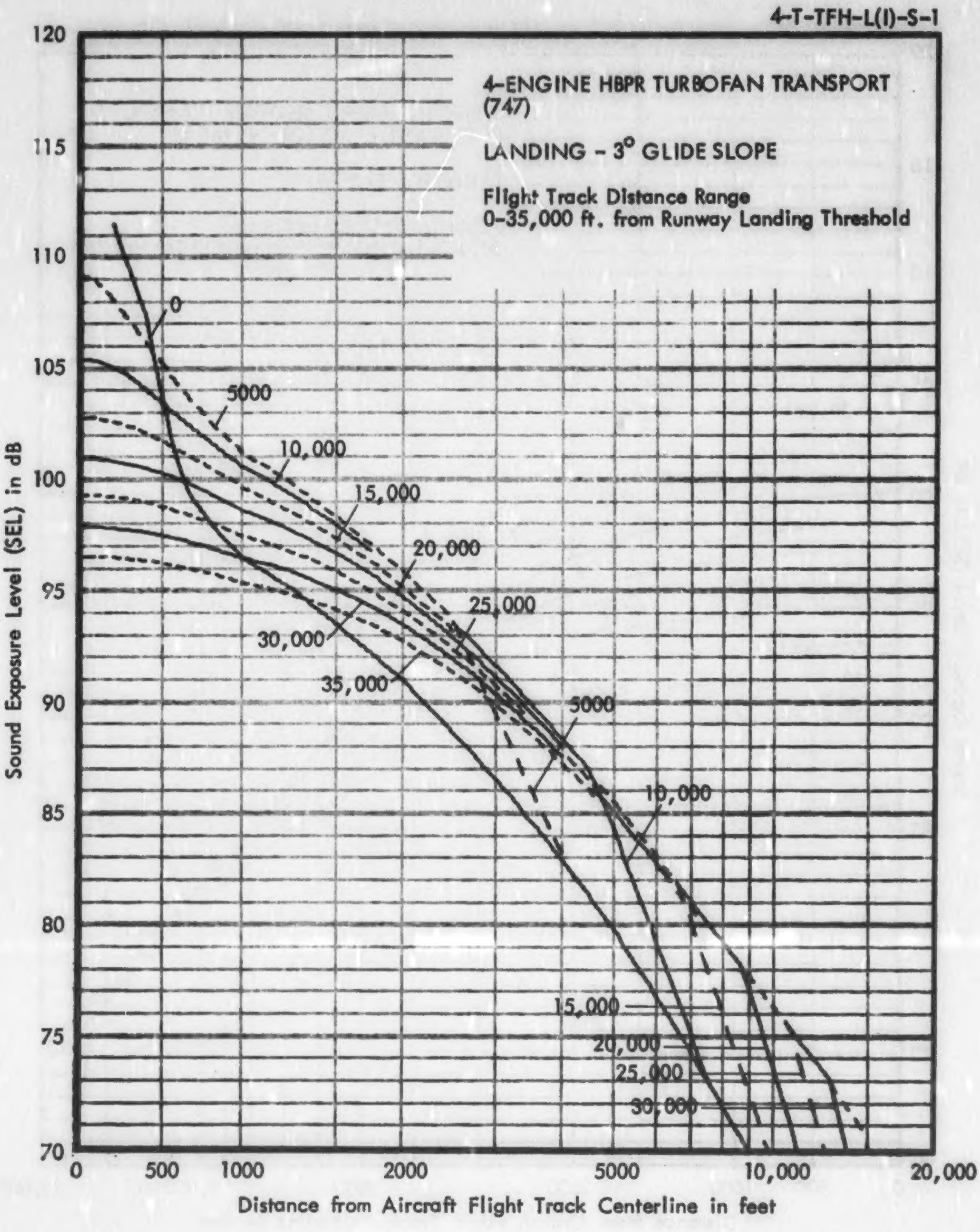

4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
50,000-140,000 ft. from start of Takeoff Roll
50,000
60,000
70,000
80,000
100,000
120,000
140,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE >2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
10,000
0
4000
6000
8000
10,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

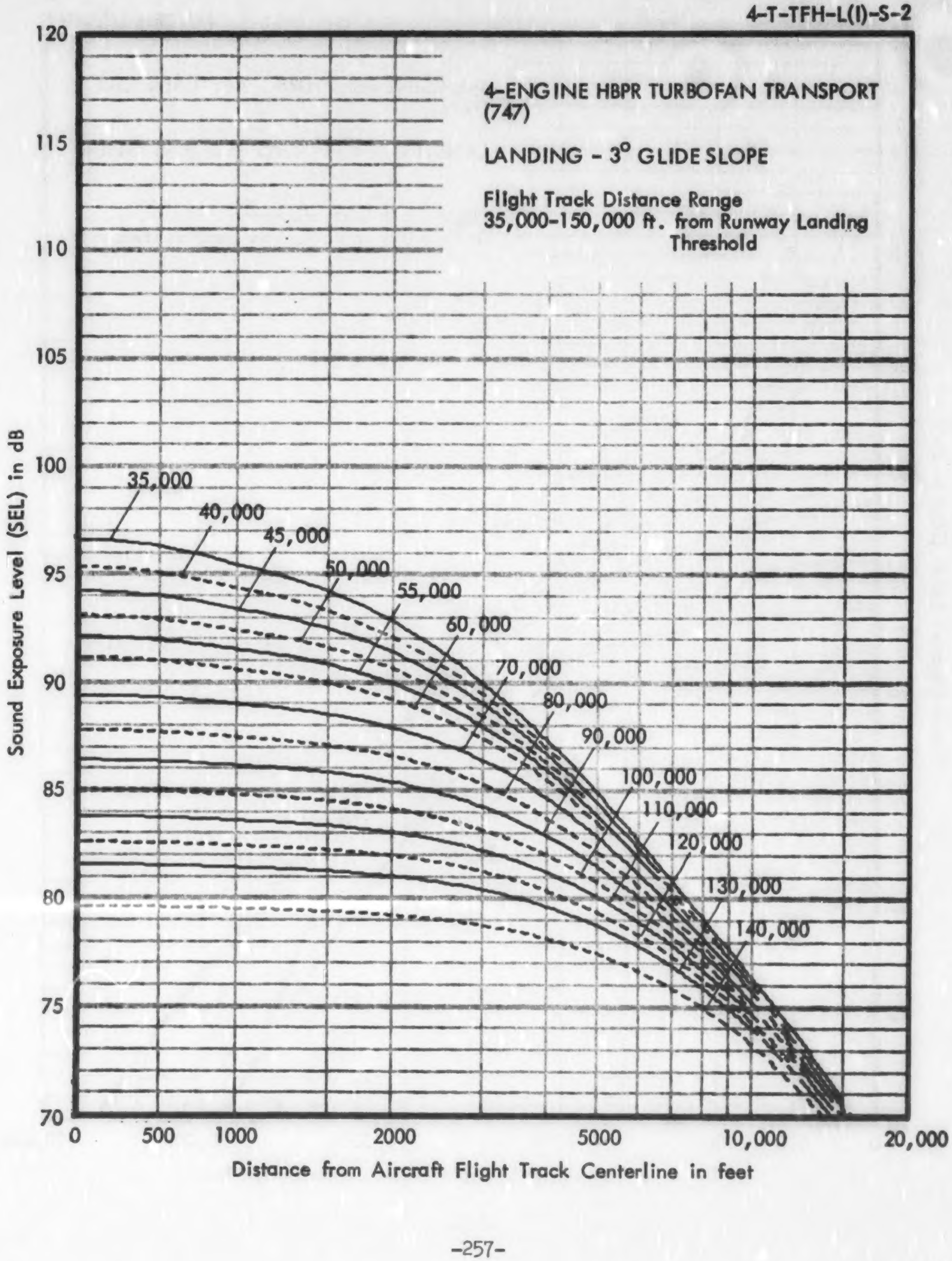

4-T-TFH-TO(III)-F-2
4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE >2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
10,000-50,000 ft. from start of Takeoff Roll
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE HBPR TURBOFAN TRANSPORT
(747) RANGE >2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
50,000-140,000 ft. from start of Takeoff Roll
50,000
60,000
70,000
80,000
100,000
120,000
140,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

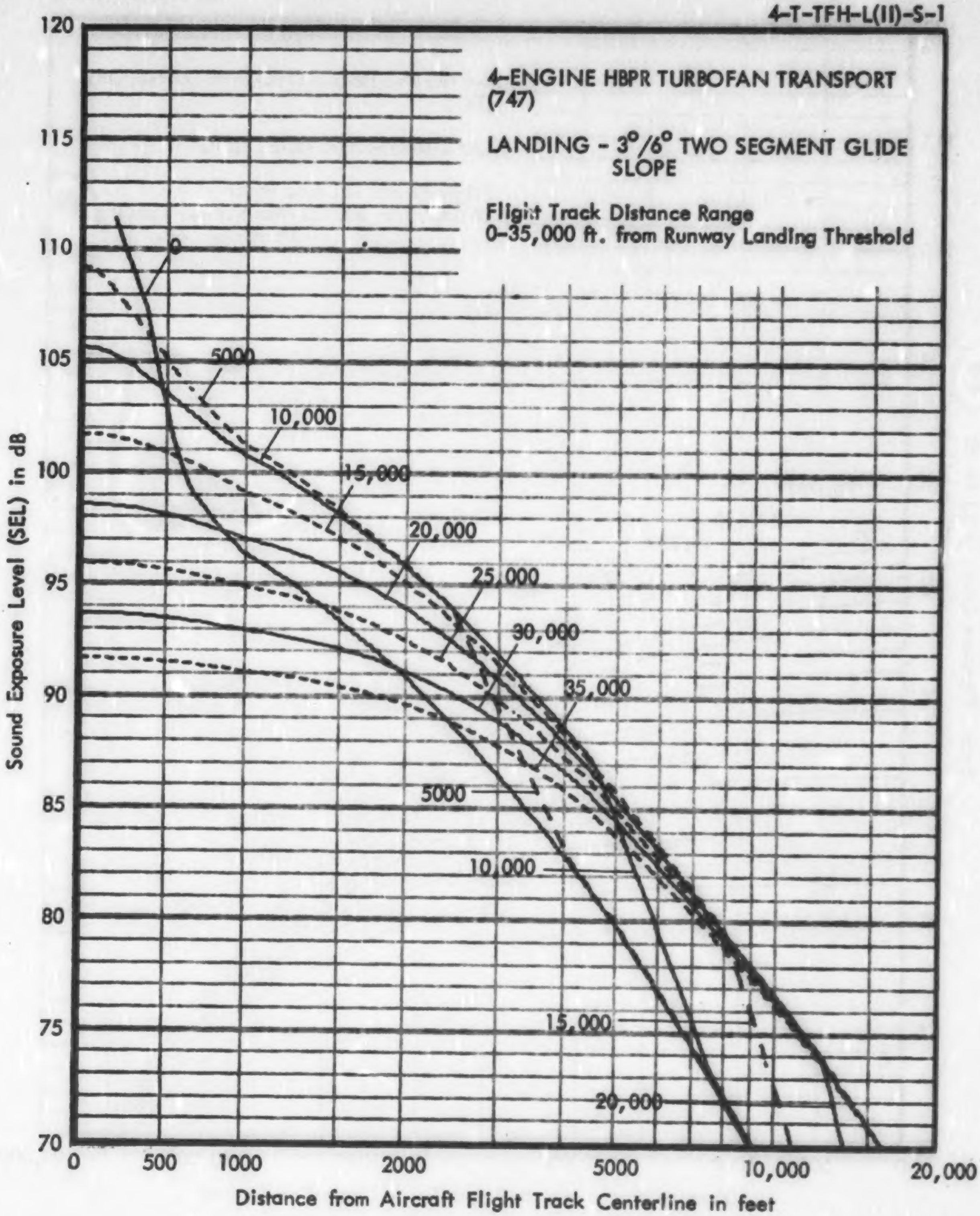
4-T-TFH-L(I)-S-1


4-ENGINE HBPR TURBOFAN TRANSPORT (747)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
5000
10,000
15,000
20,000
25,000
30,000

4-T-TFH-L(I)-S-2


4-ENGINE HBPR TURBOFAN TRANSPORT (747)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range 35,000-150,000 ft. from Runway Landing Threshold
35,000
40,000
45,000
50,000
55,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
130,000
140,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

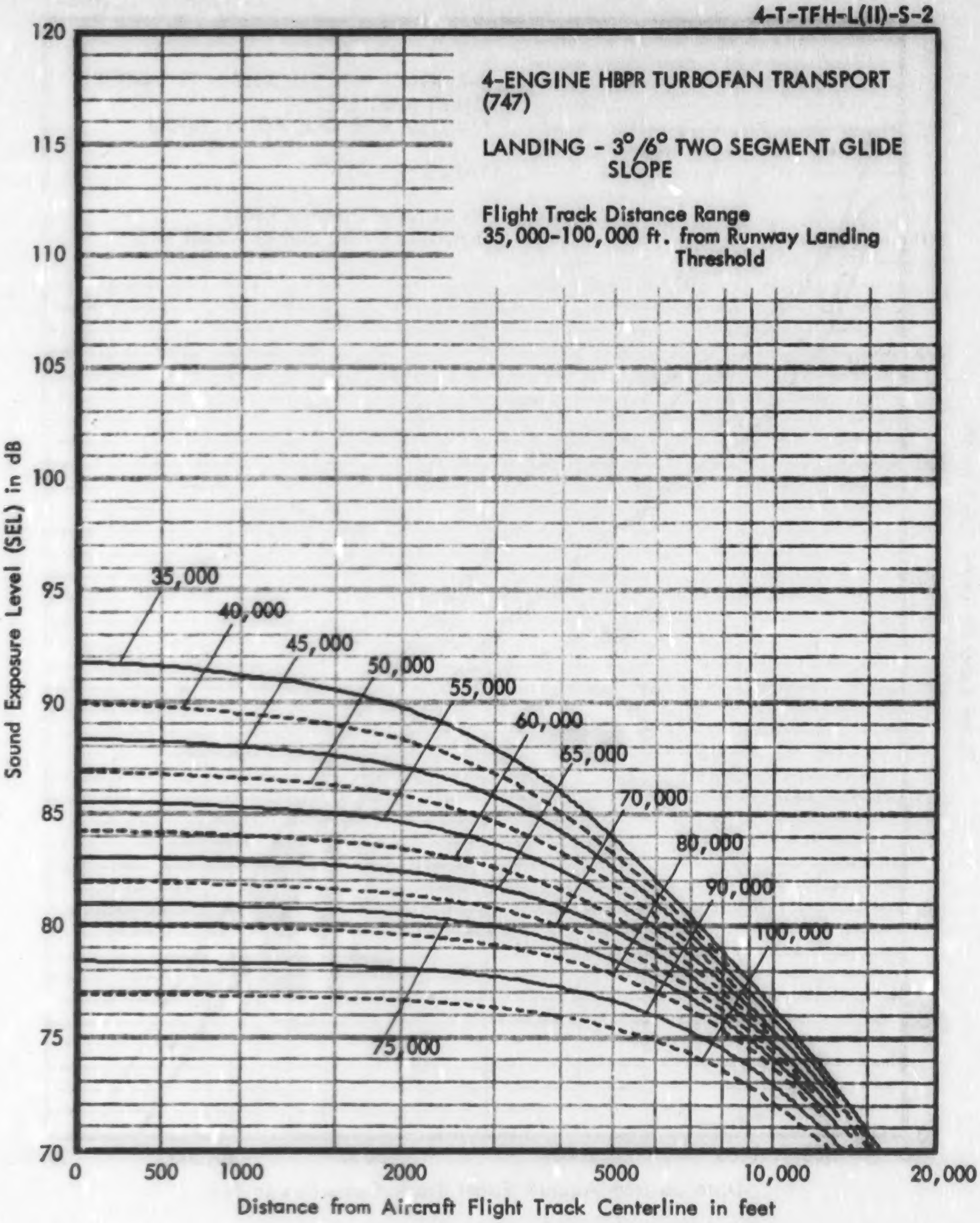
4-T-TFH-L(II)-S-1



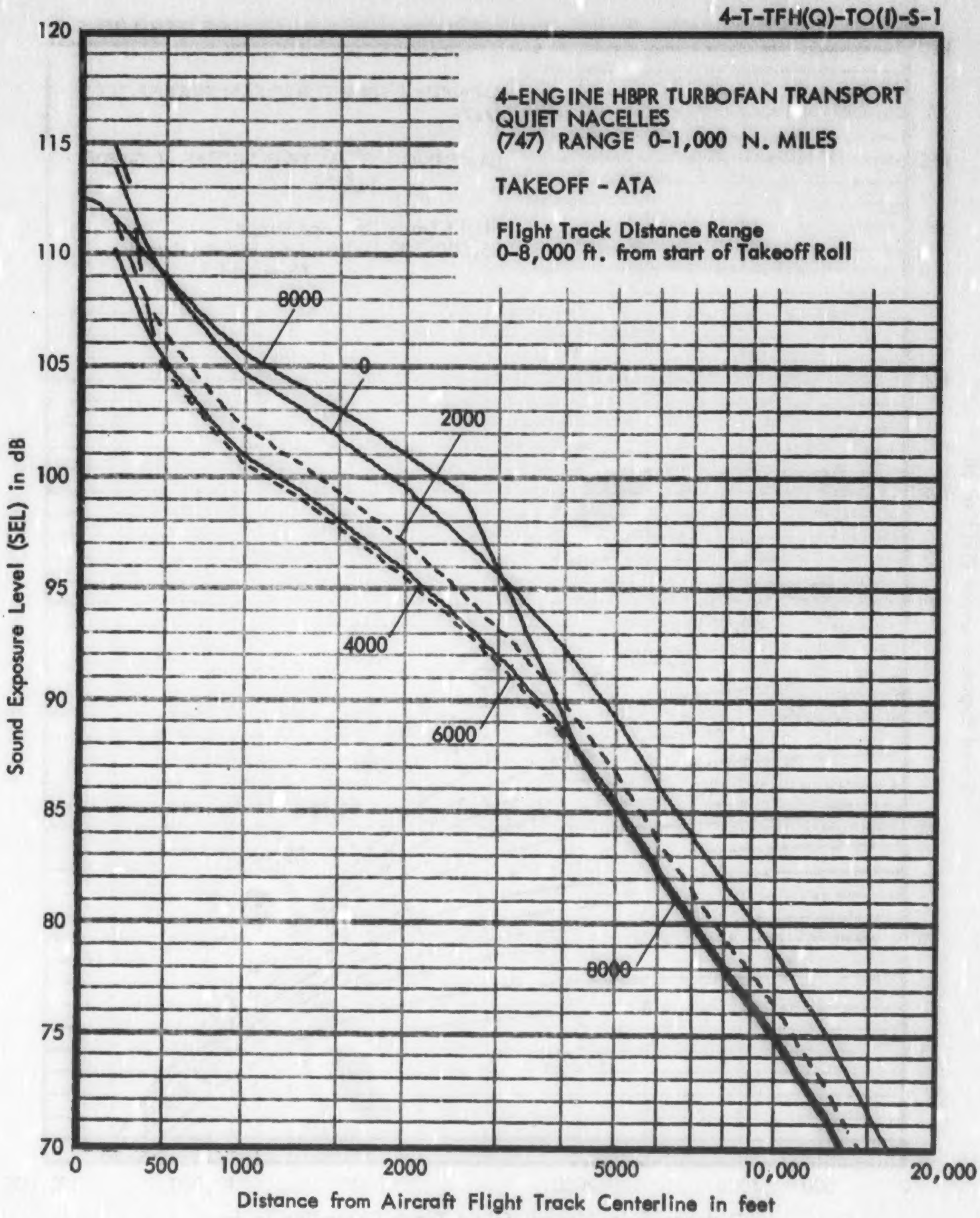
4-ENGINE HBPR TURBOFAN TRANSPORT (747)

LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE

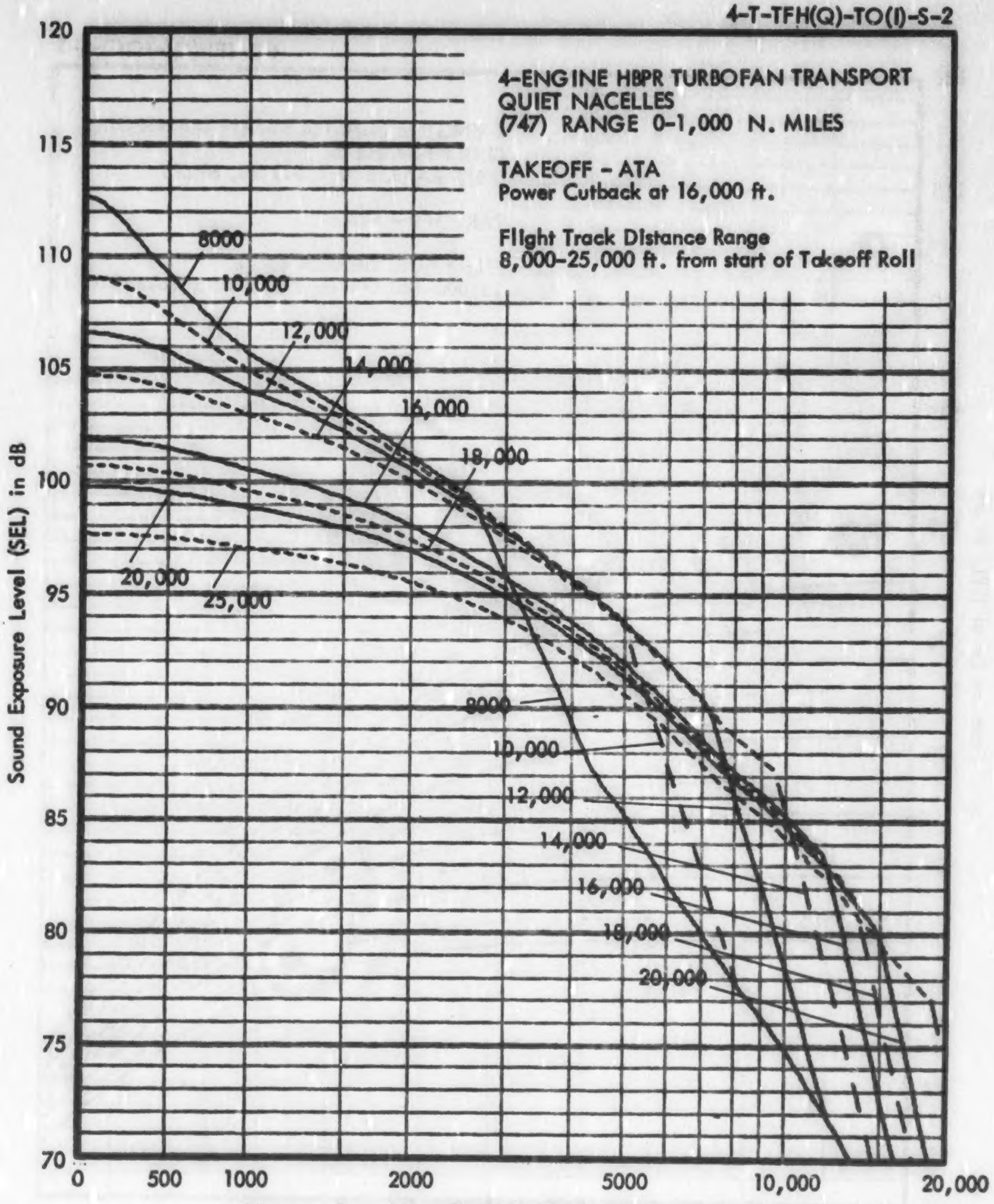
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold


4-ENGINE HBPR TURBOFAN TRANSPORT (747)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range 35,000-100,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
50,000
55,000
60,000
65,000
70,000
75,000
80,000
90,000
100,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

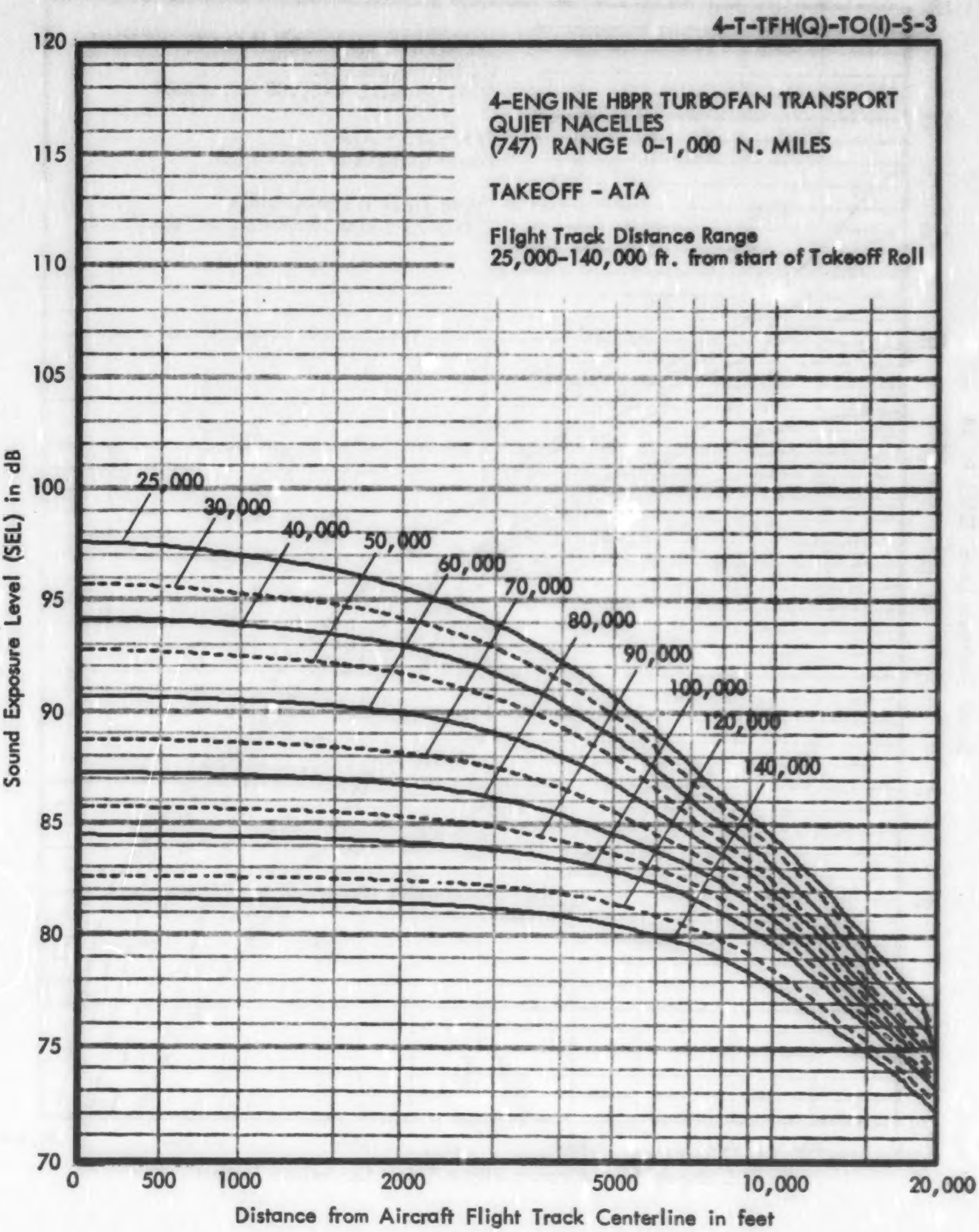
4-T-TFH(Q)-TO(I)-S-1



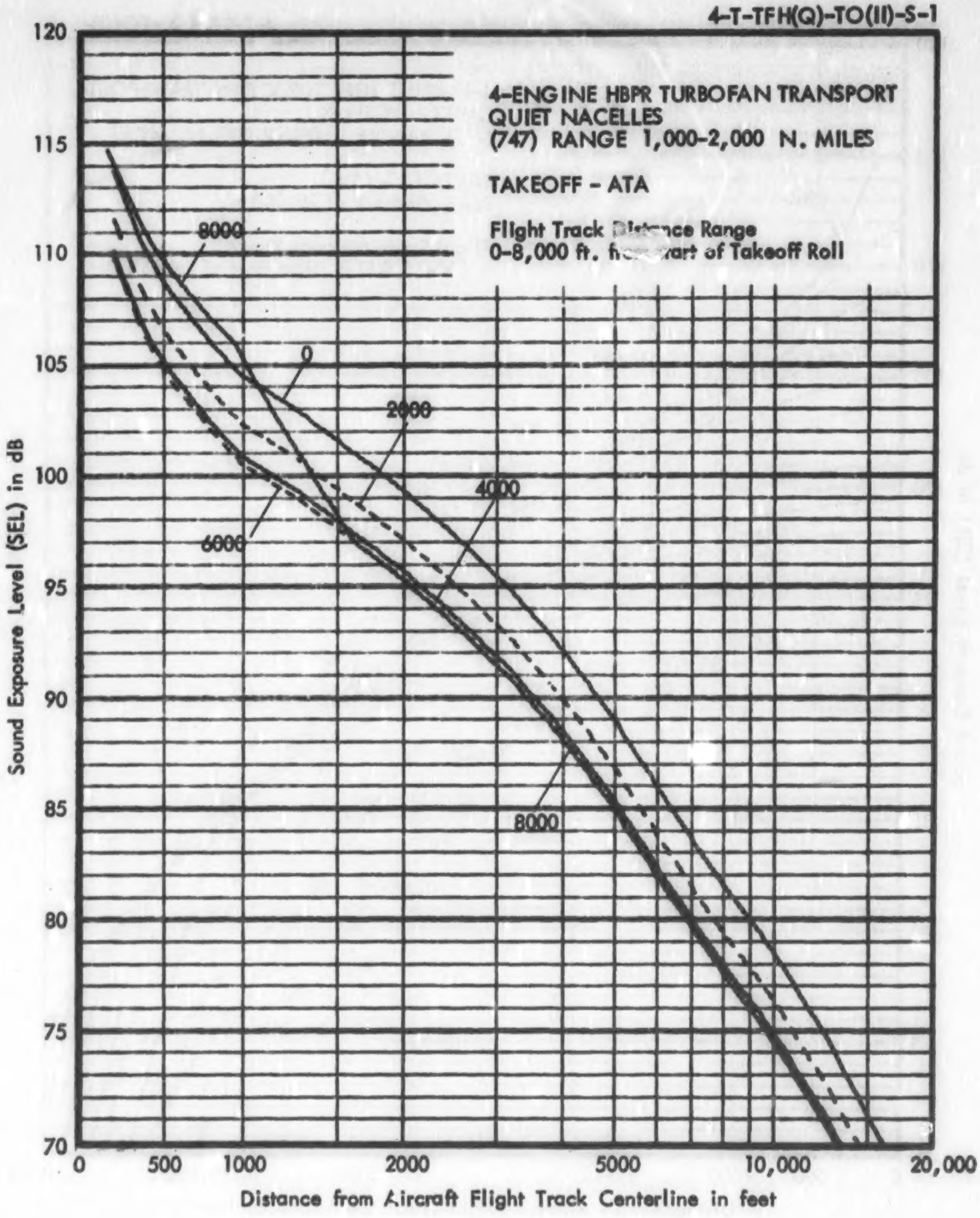
4-T-TFH(Q)-TO(I)-S-2

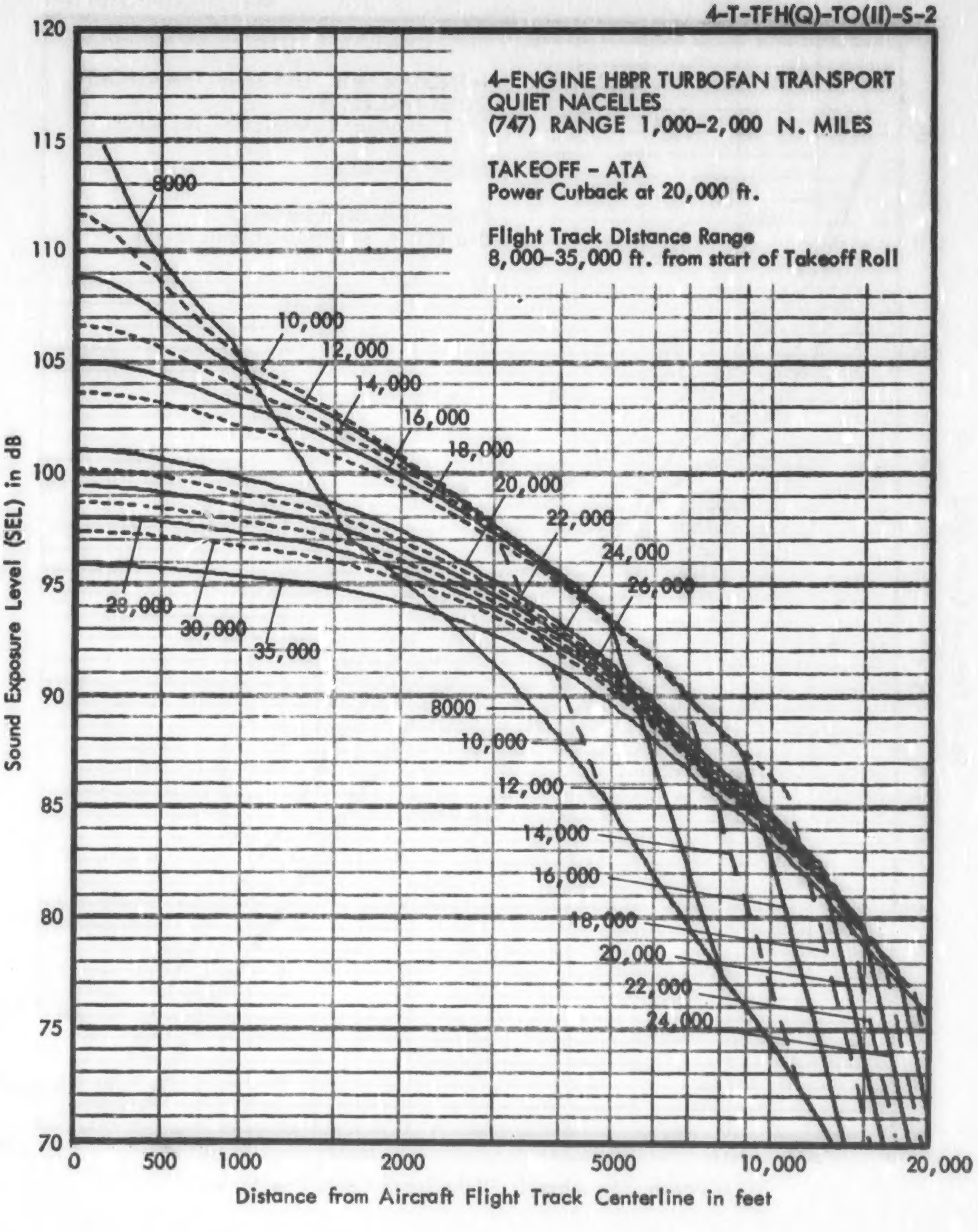


4-T-TFH(Q)-TO(I)-S-3

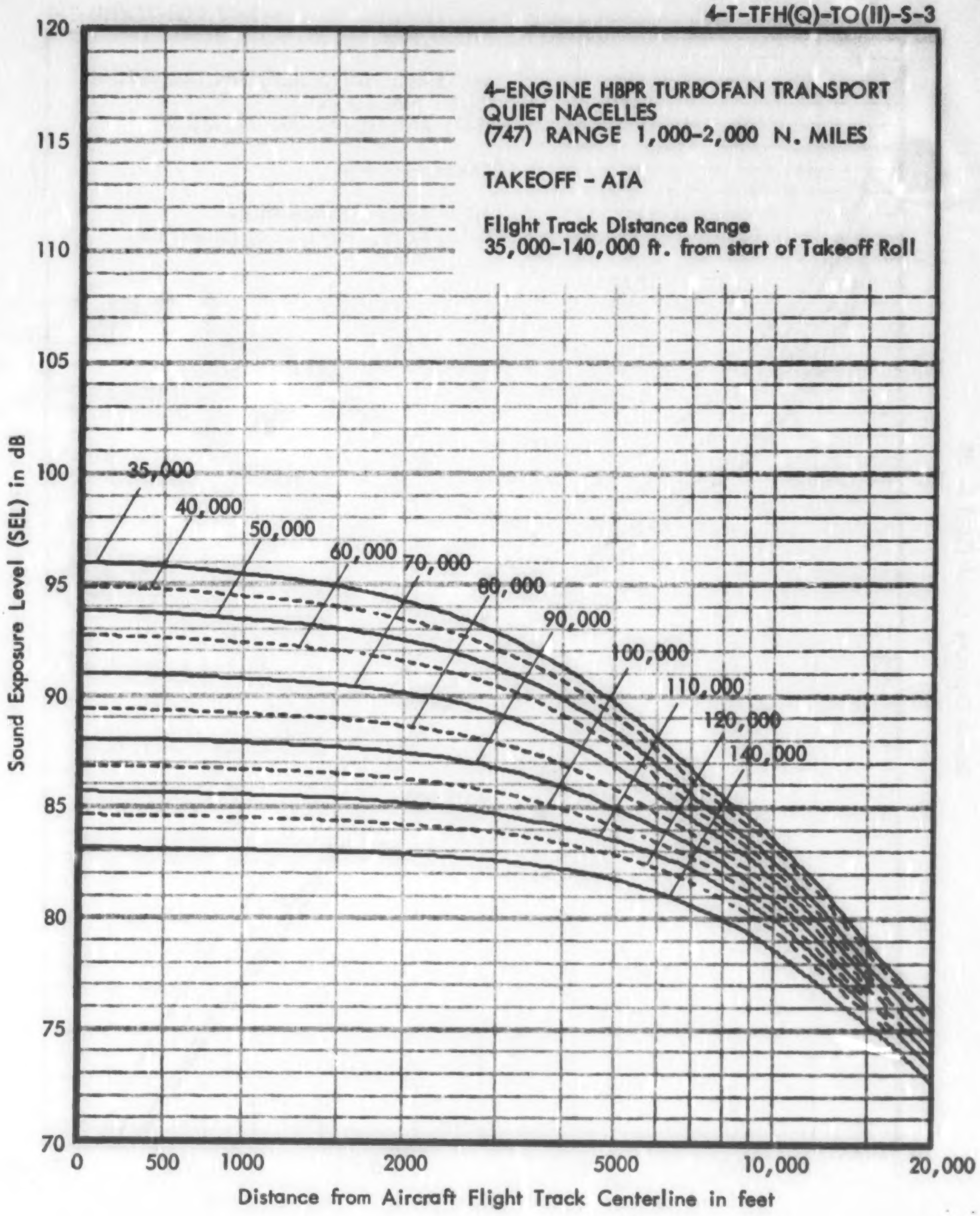


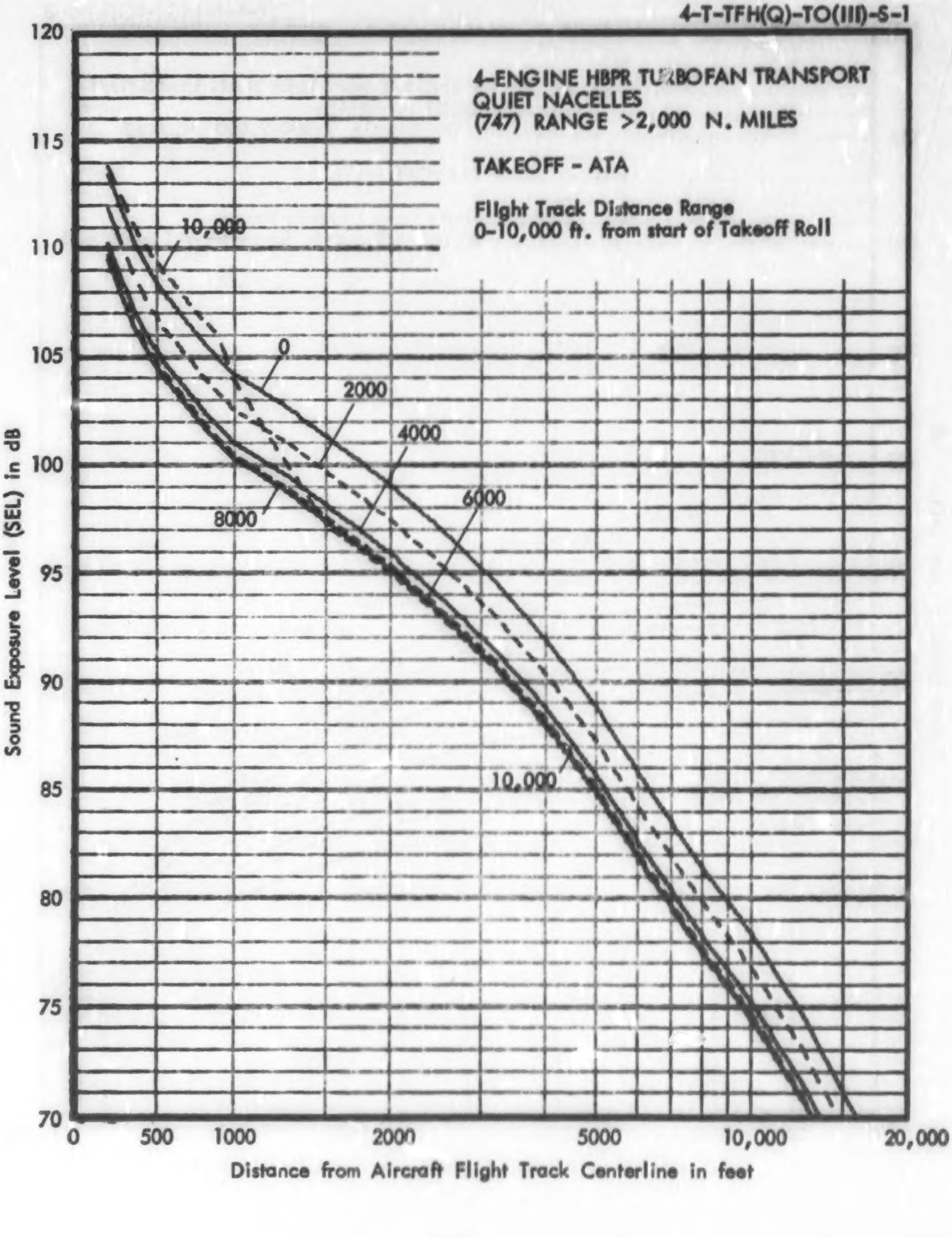
4-T-TFH(Q)-TO(II)-S-1

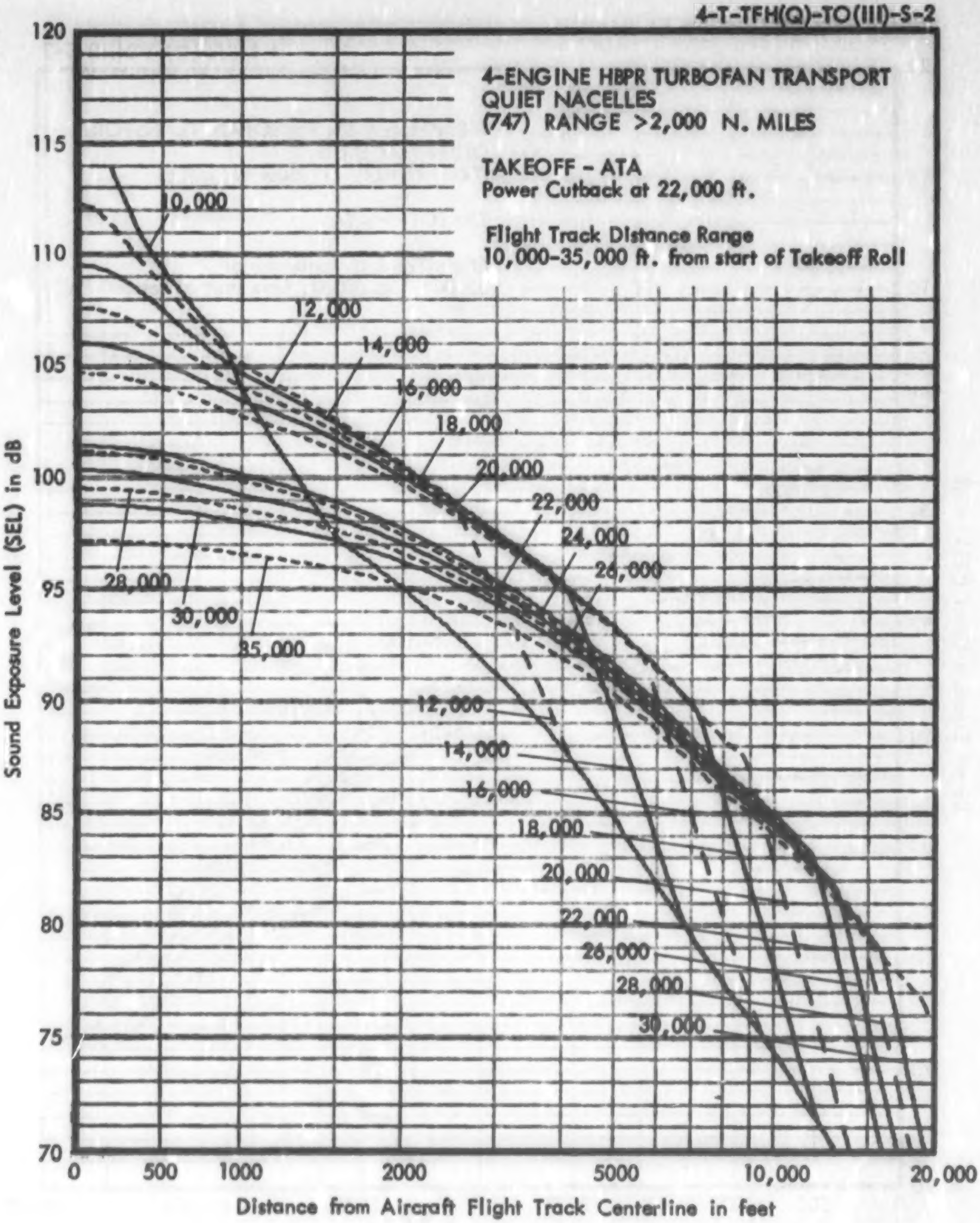


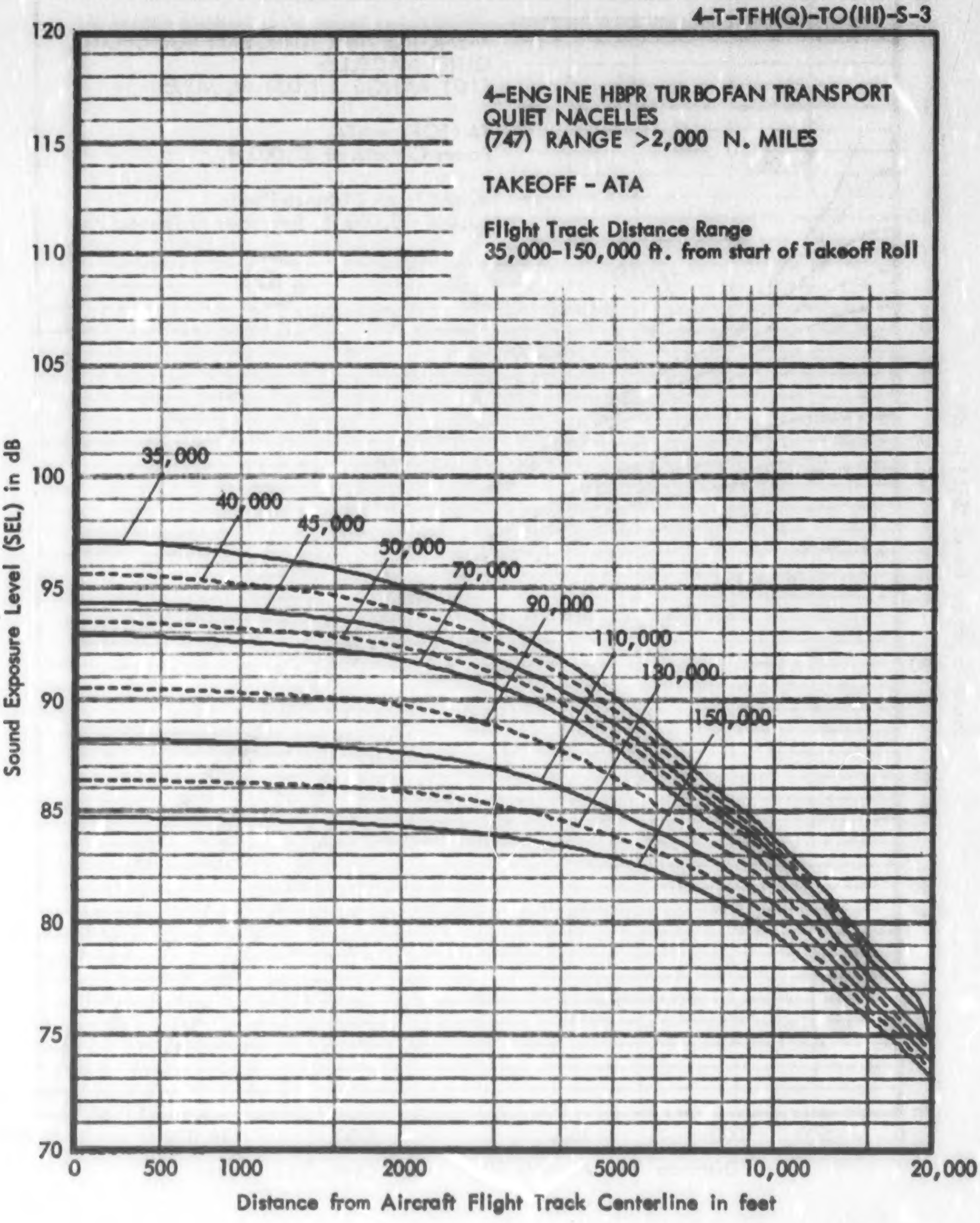

4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - ATA
Power Cutback at 20,000 ft.
Flight Track Distance Range
8,000-35,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
35,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000

4-T-TFH(Q)-TO(II)-S-3

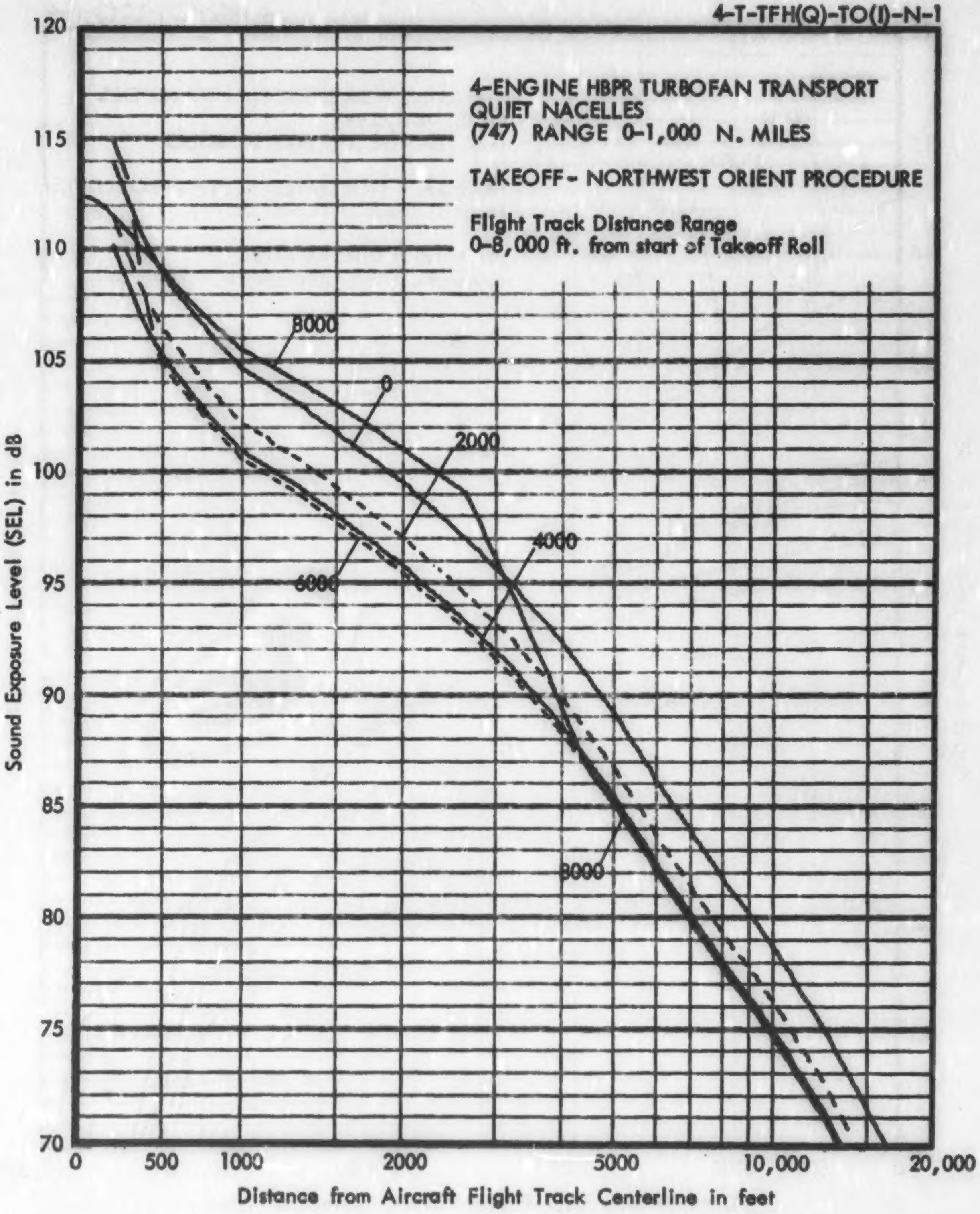



4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE >2,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
10,000
0
2000
4000
6000
8000
10,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

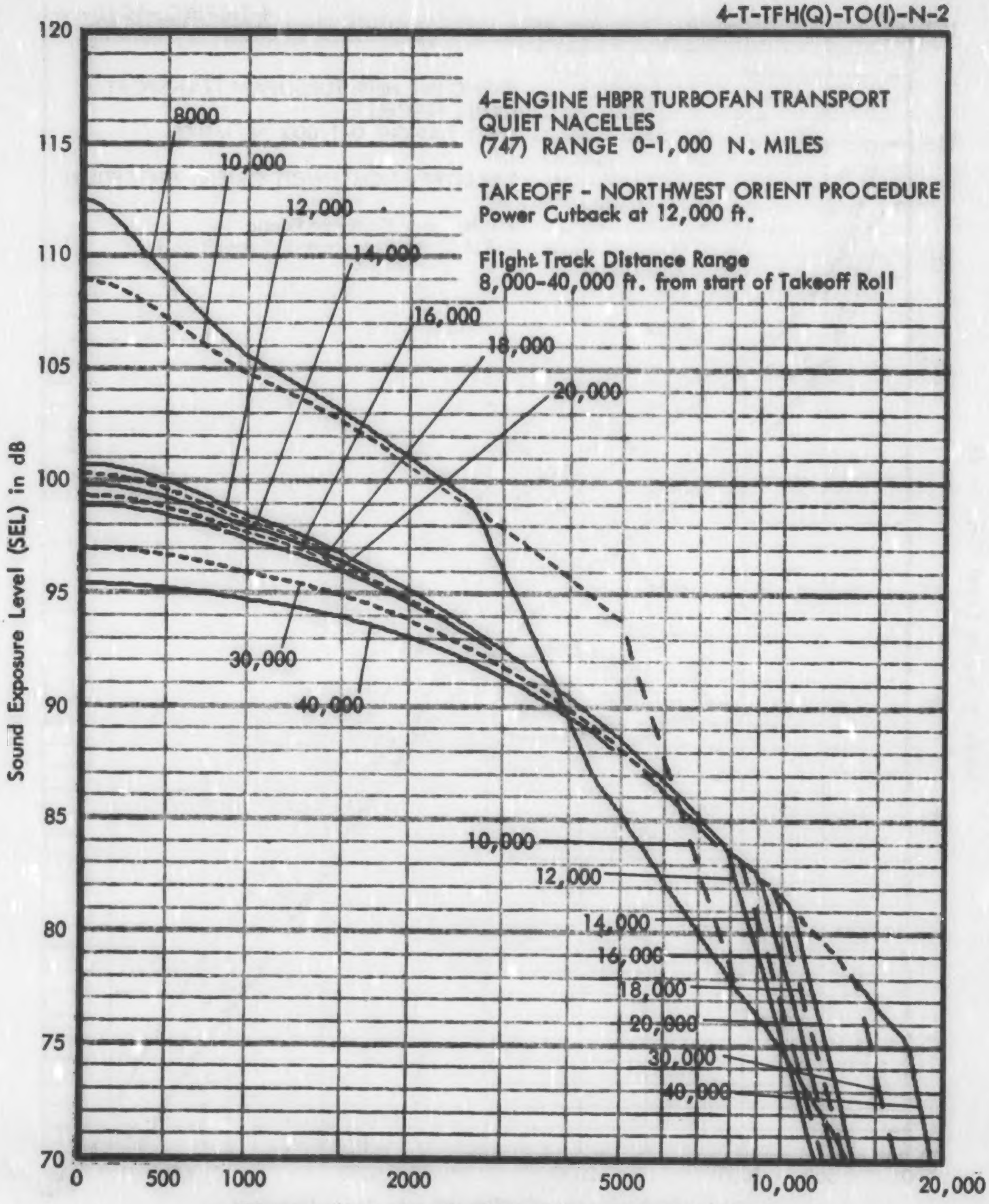

4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE >2,000 N. MILES
TAKEOFF - ATA
Power Cutback at 22,000 ft.
Flight Track Distance Range
10,000-35,000 ft. from start of Takeoff Roll
10,000
12,000
14,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
35,000
12,000
14,000
16,000
18,000
20,000
22,000
26,000
28,000
30,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE >2,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
35,000-150,000 ft. from start of Takeoff Roll
35,000
40,000
45,000
50,000
70,000
90,000
110,000
130,000
150,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

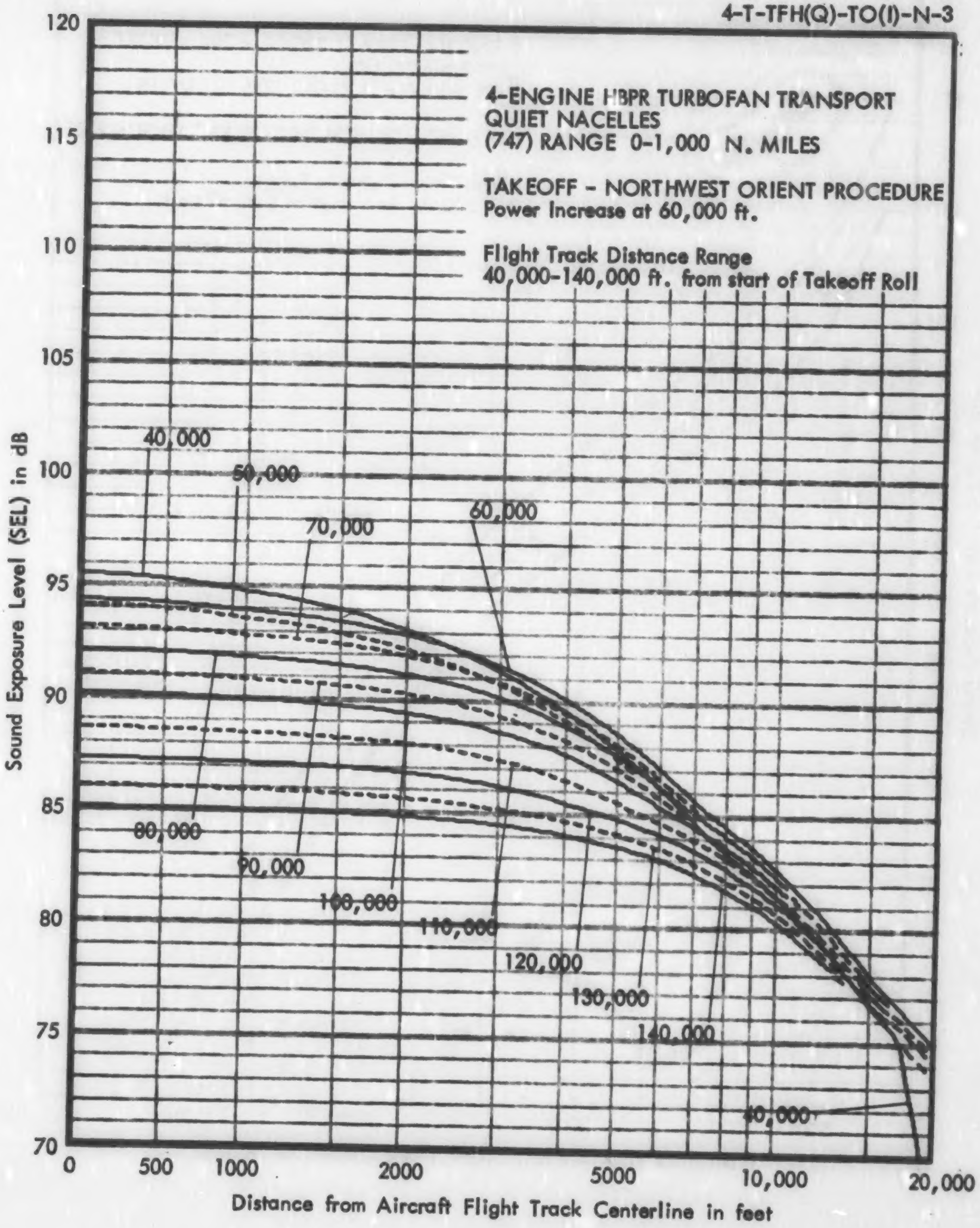
4-T-TFH(Q)-TO(I)-N-1

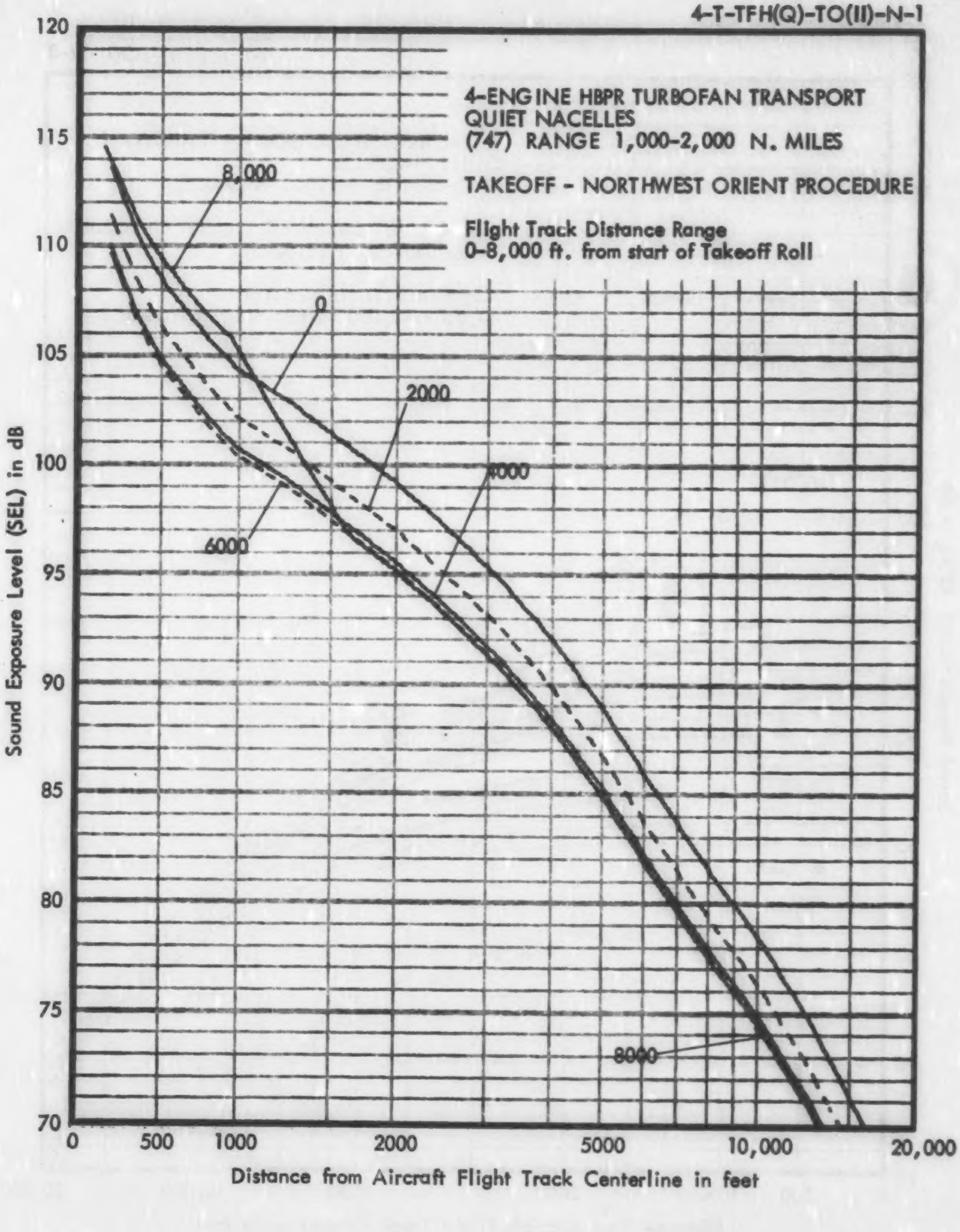


4-T-TFH(Q)-TO(I)-N-2

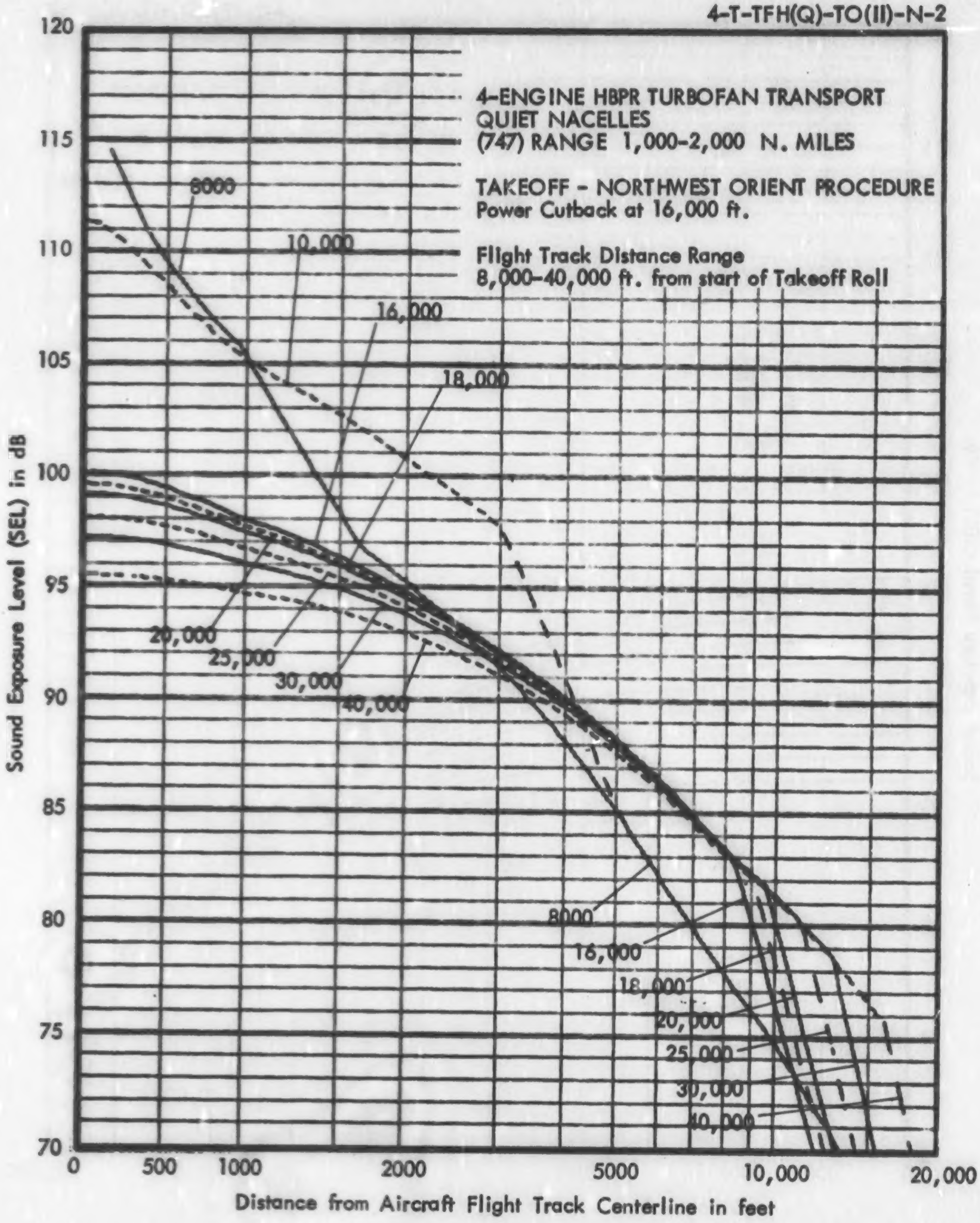


4-T-TFH(Q)-TO(I)-N-3

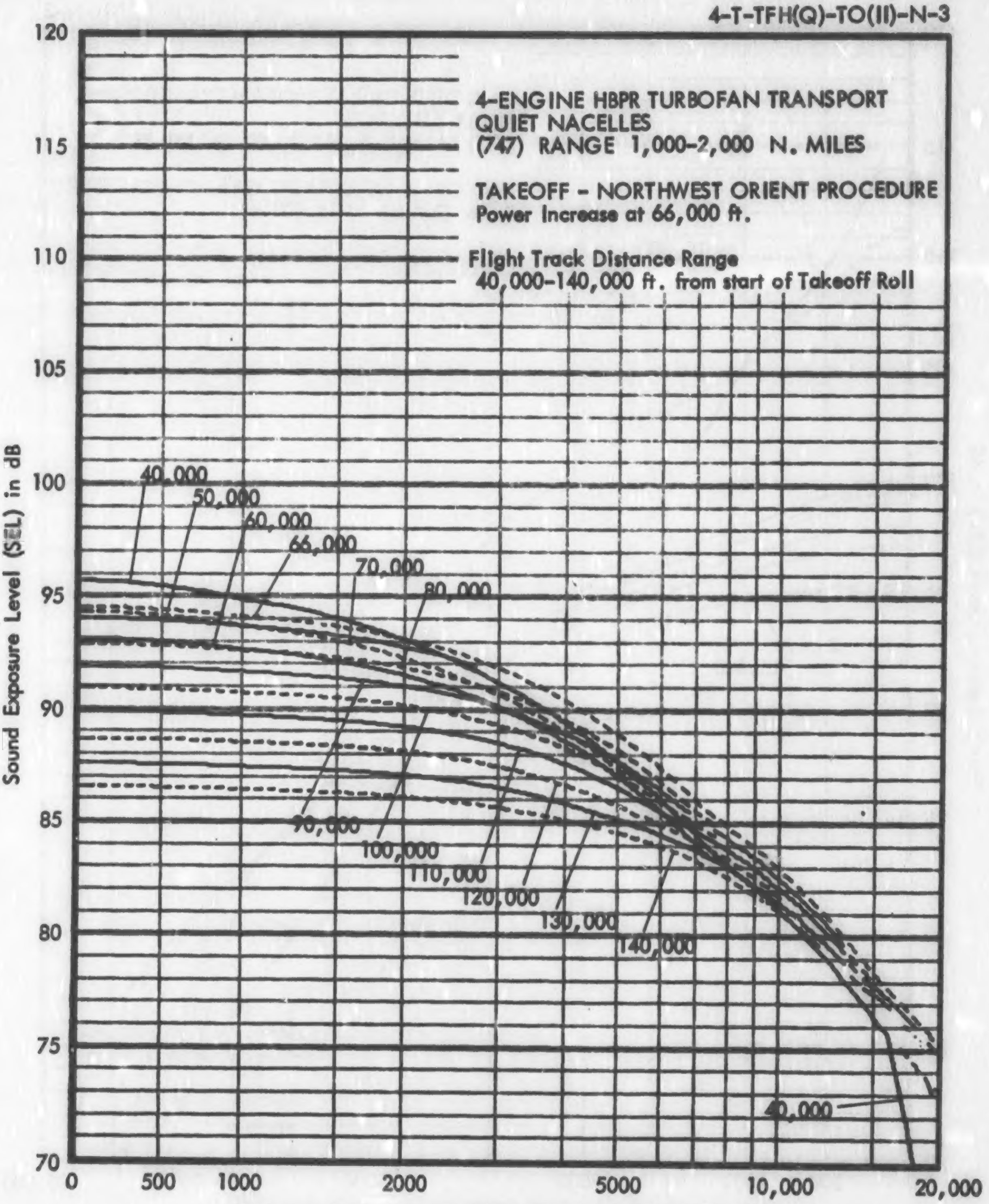


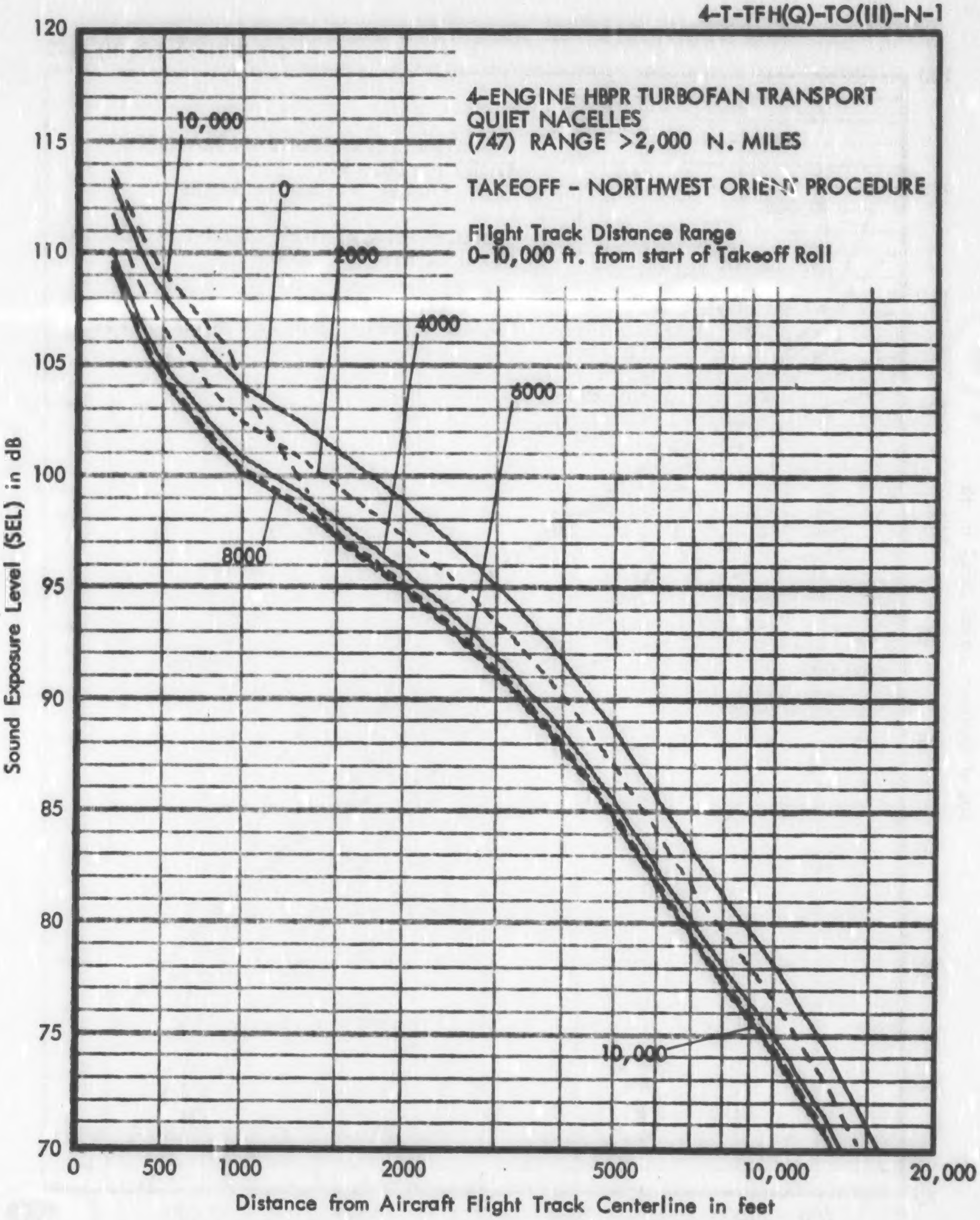

4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
8,000
0
2000
4000
6000
8000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

4-T-TFH(Q)-TO(II)-N-2

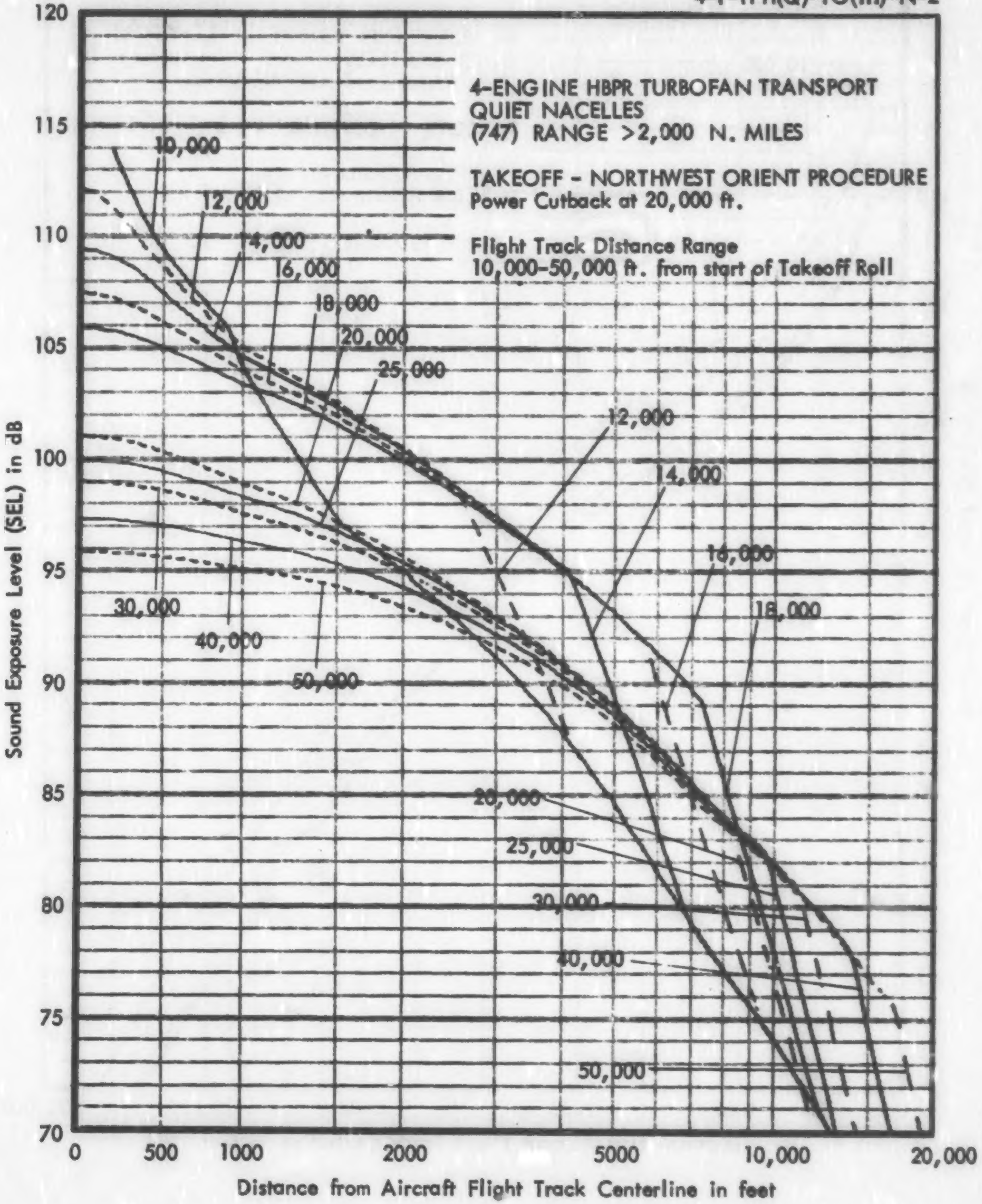


4-T-TFH(Q)-TO(II)-N-3

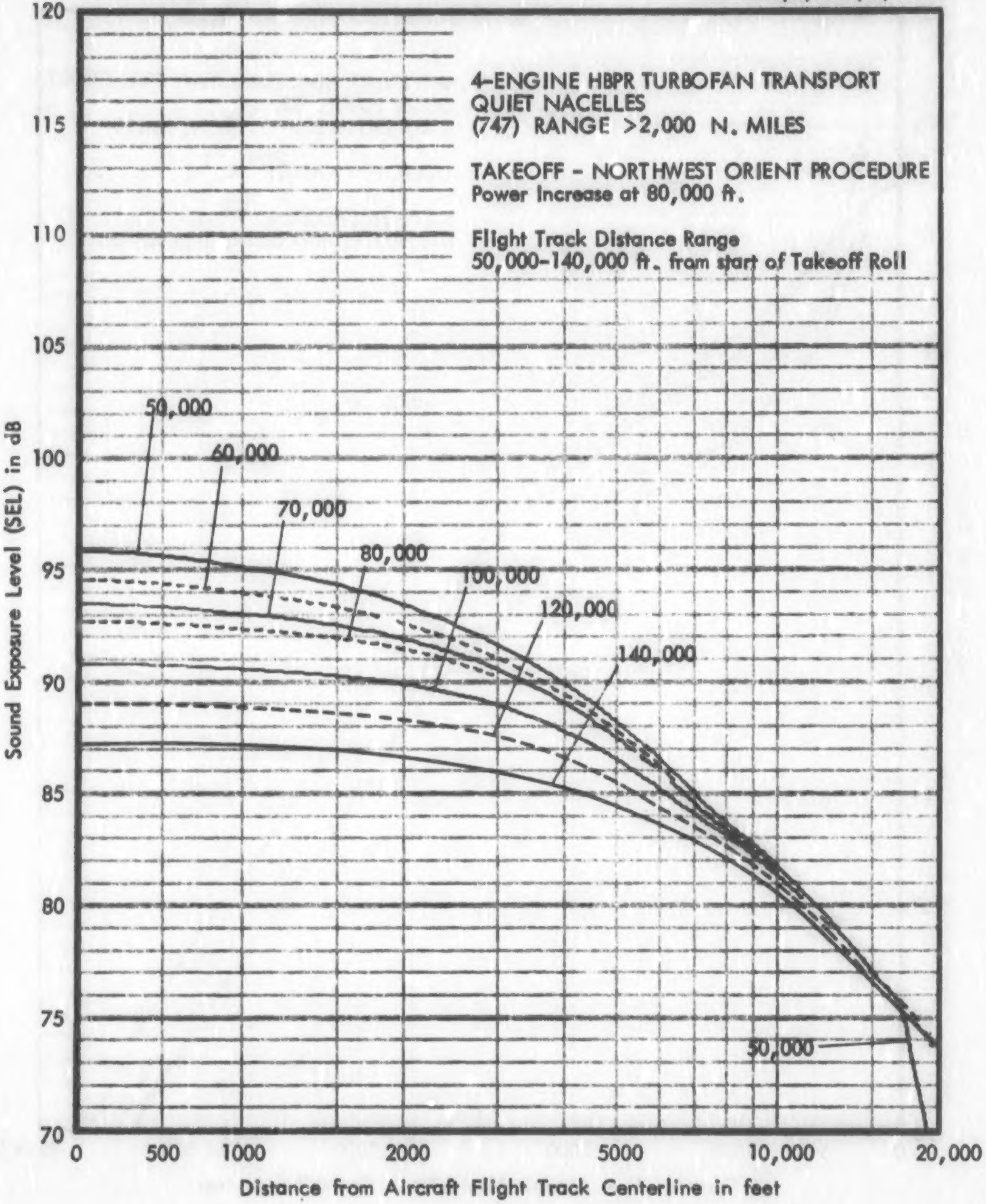



4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE >2,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
10,000
0
2000
4000
6000
8000
10,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

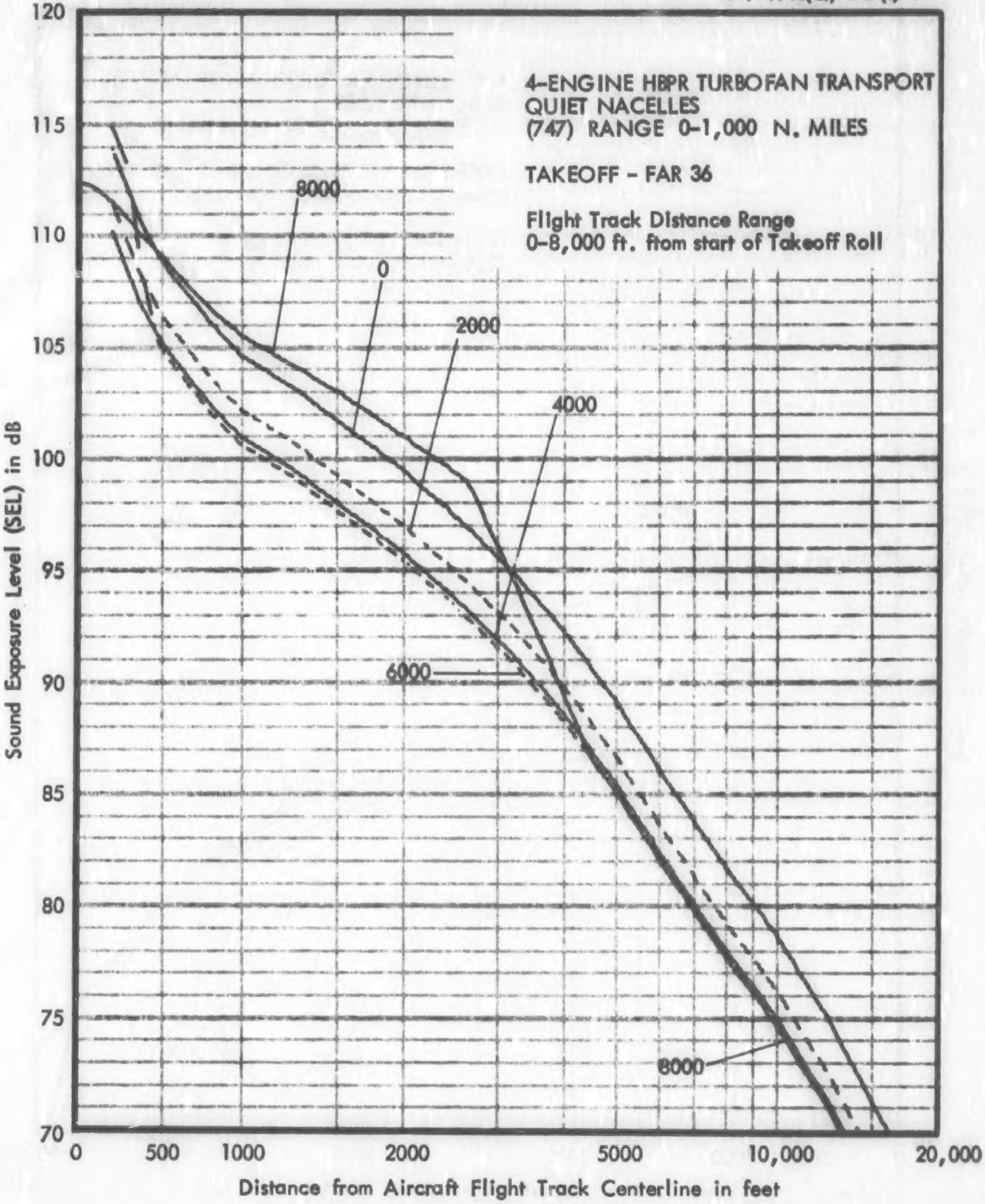
4-T-TFH(Q)-TO(III)-N-2



4-T-TFH(Q)-TO(III)-N-3



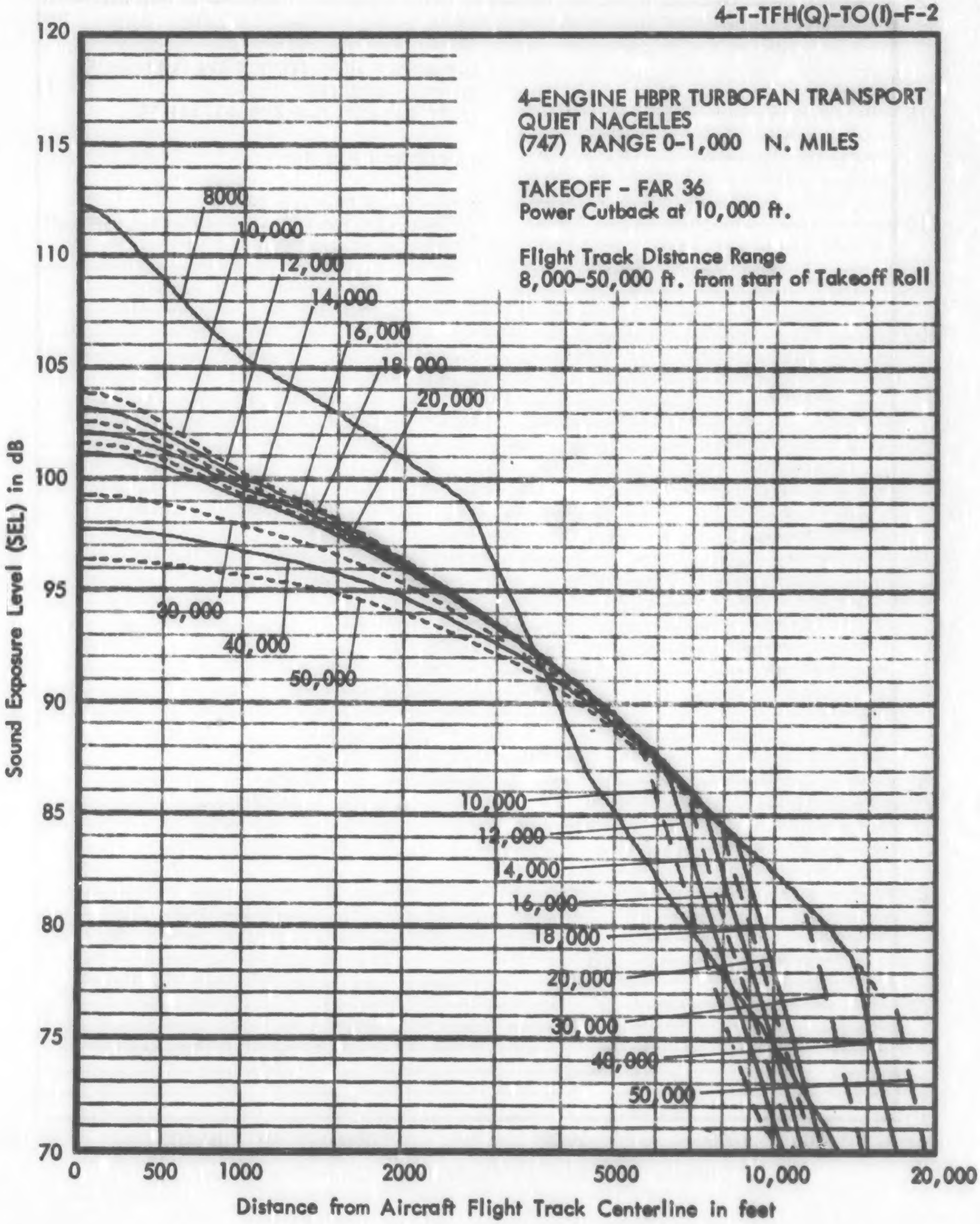
4-T-TFH(Q)-TO(I)-F-1



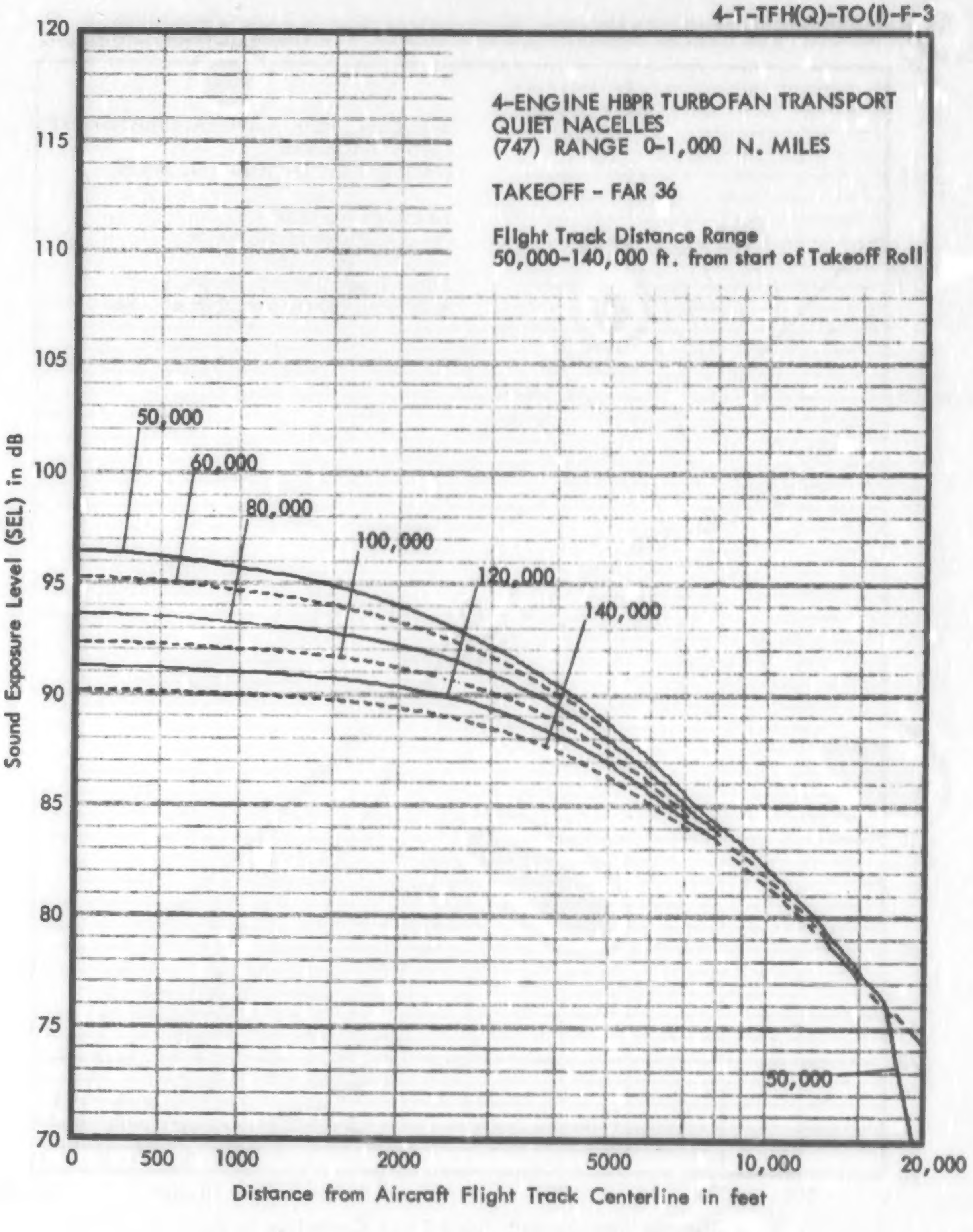
4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE 0-1,000 N. MILES

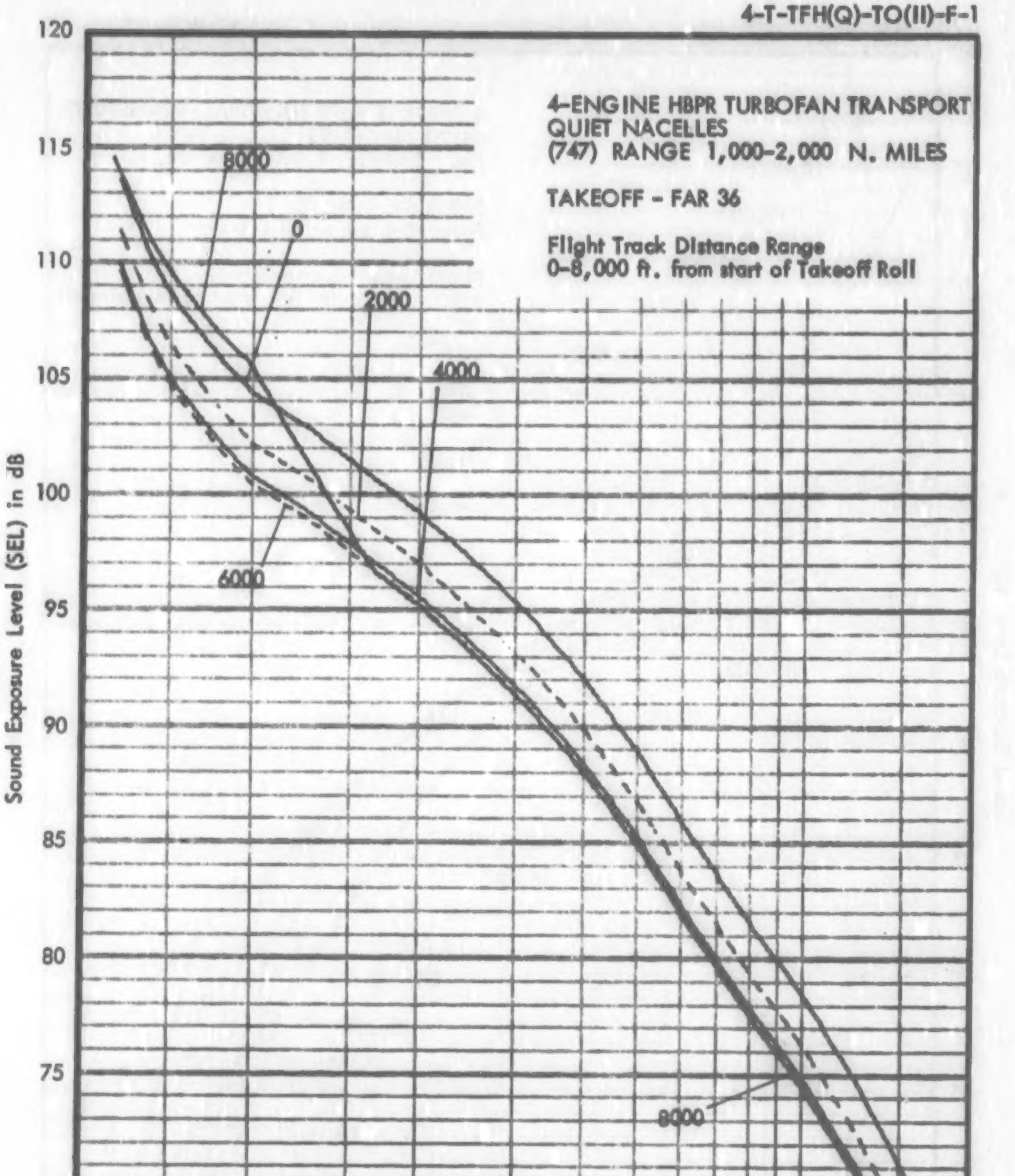
TAKEOFF - FAR 36

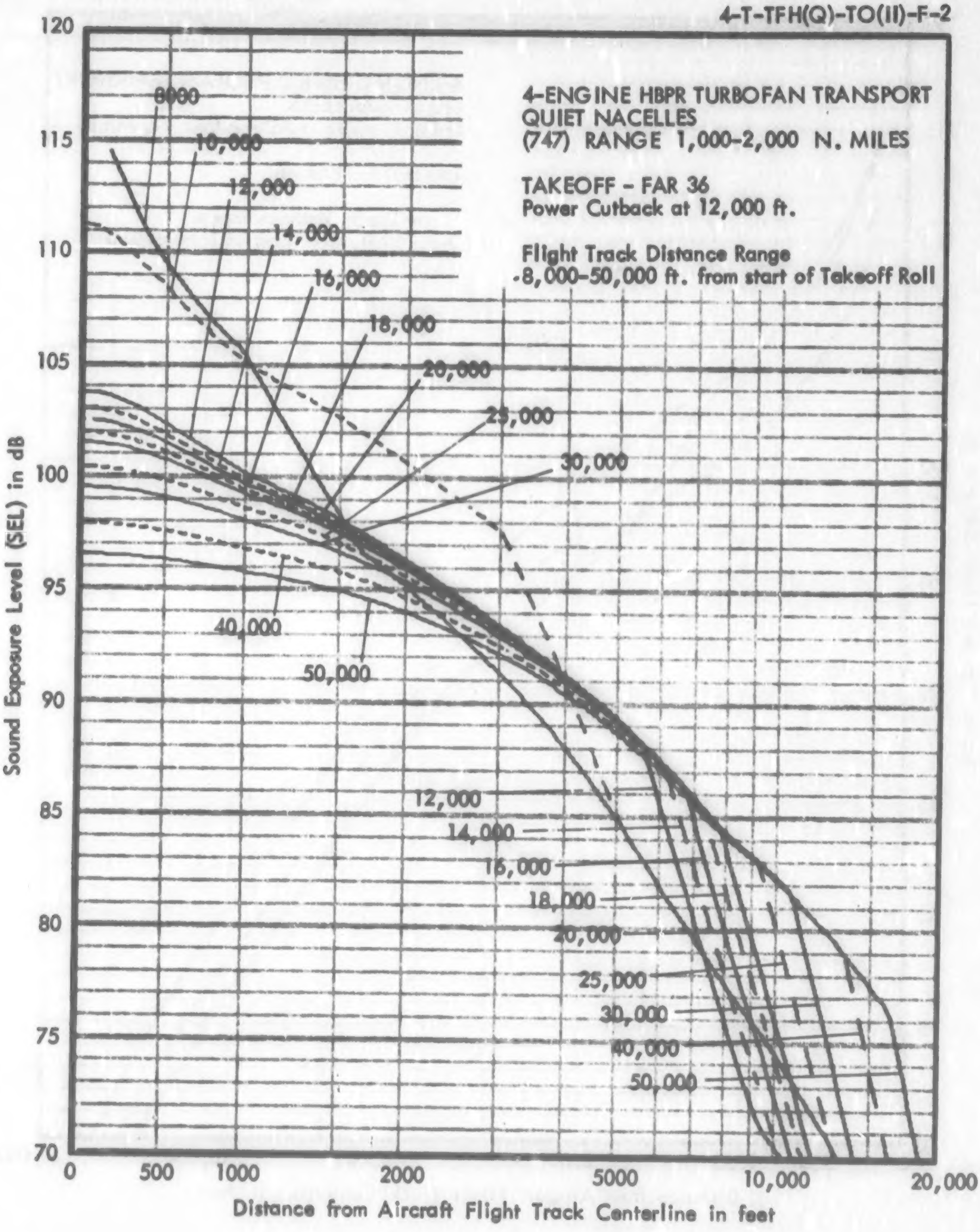
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll


4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE 0-1,000 N. MILES
TAKEOFF - FAR 36
Power Cutback at 10,000 ft.
Flight Track Distance Range
8,000-50,000 ft. from start of Takeoff Roll
8000
10,000
12,000
14,000
16,000
18,000
20,000
30,000
40,000
50,000
10,000
12,000
14,000
16,000
18,000
20,000
30,000
40,000
50,000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

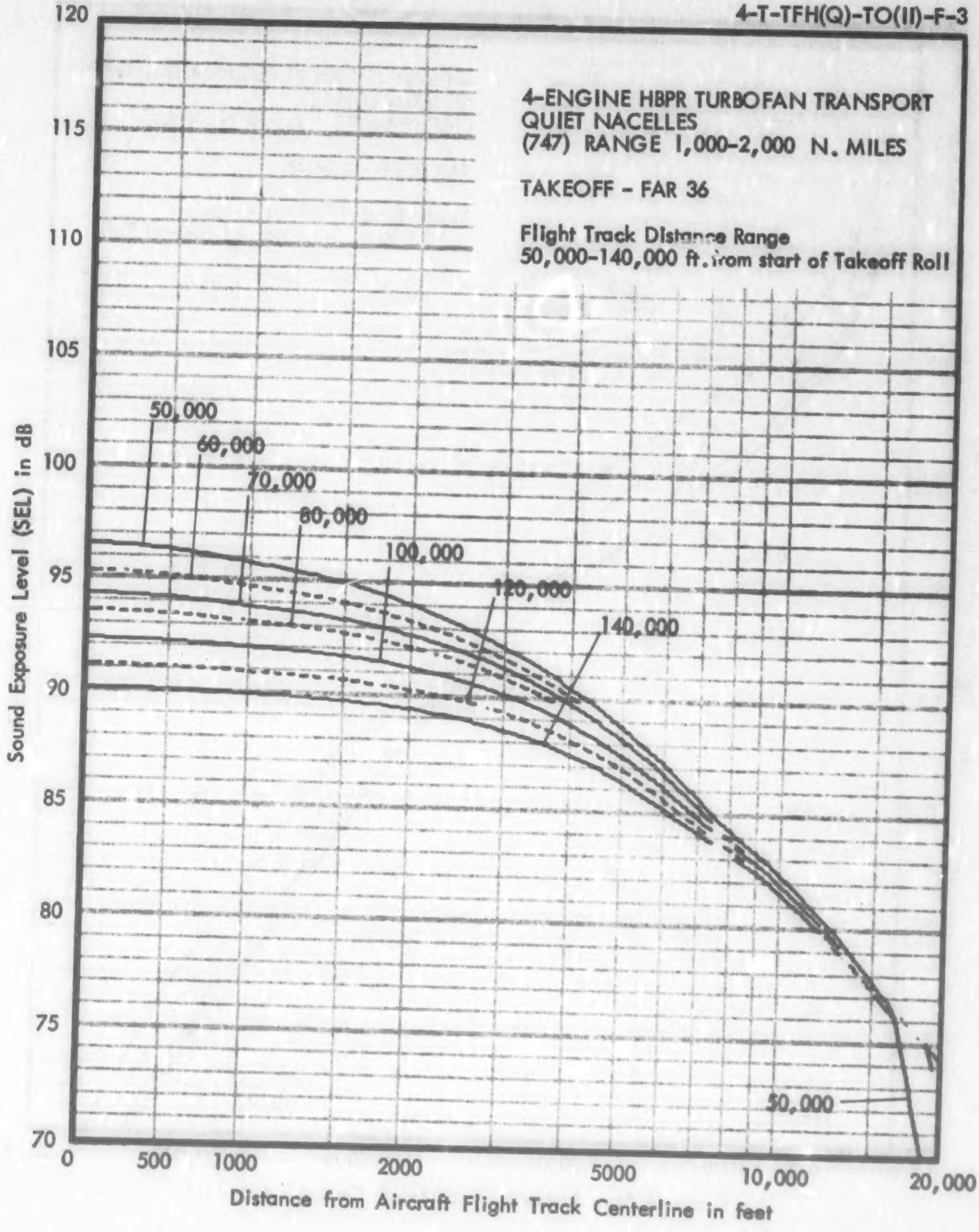
4-T-TFH(Q)-TO(I)-F-3

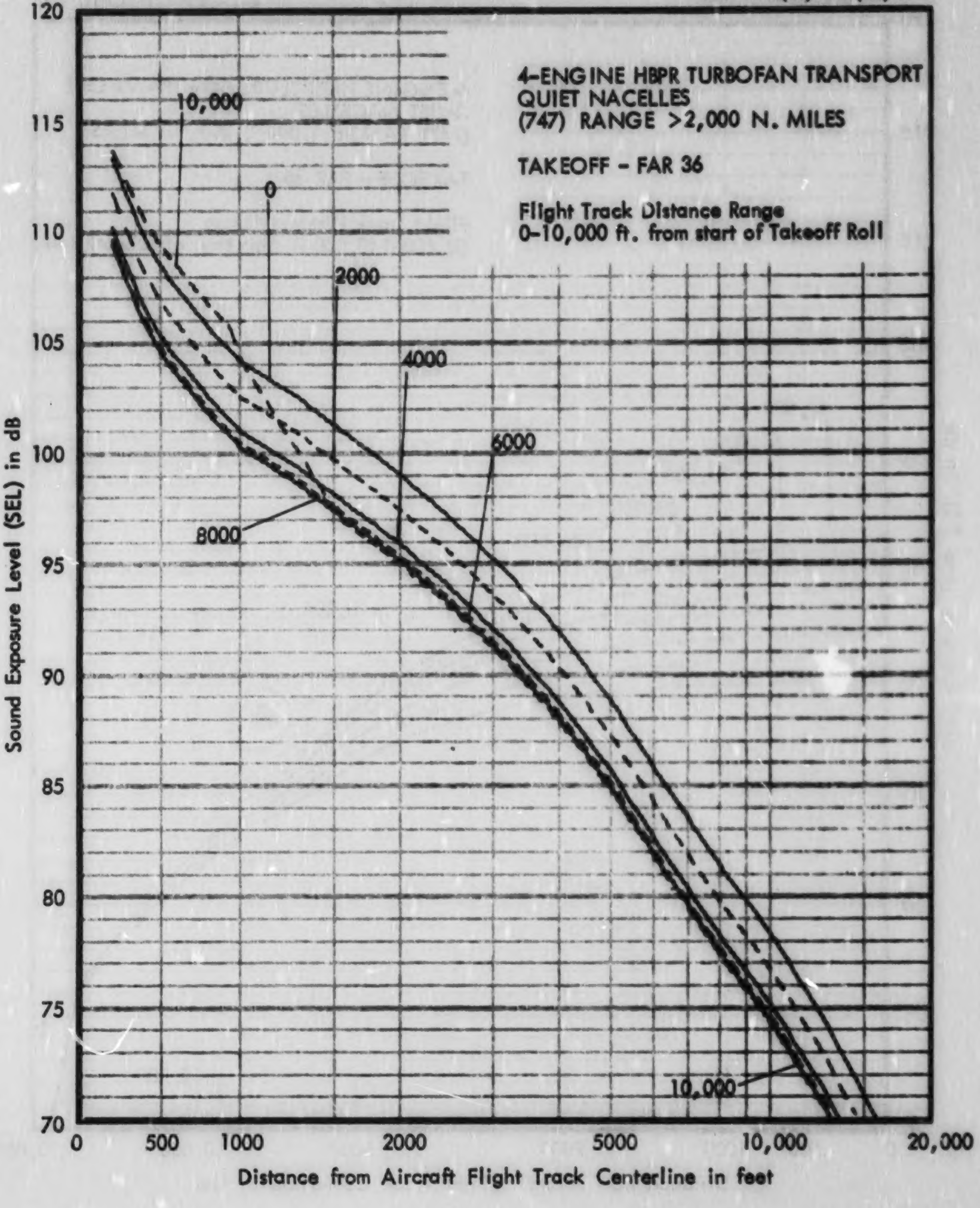



4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
8000
0
2000
4000
6000
8000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

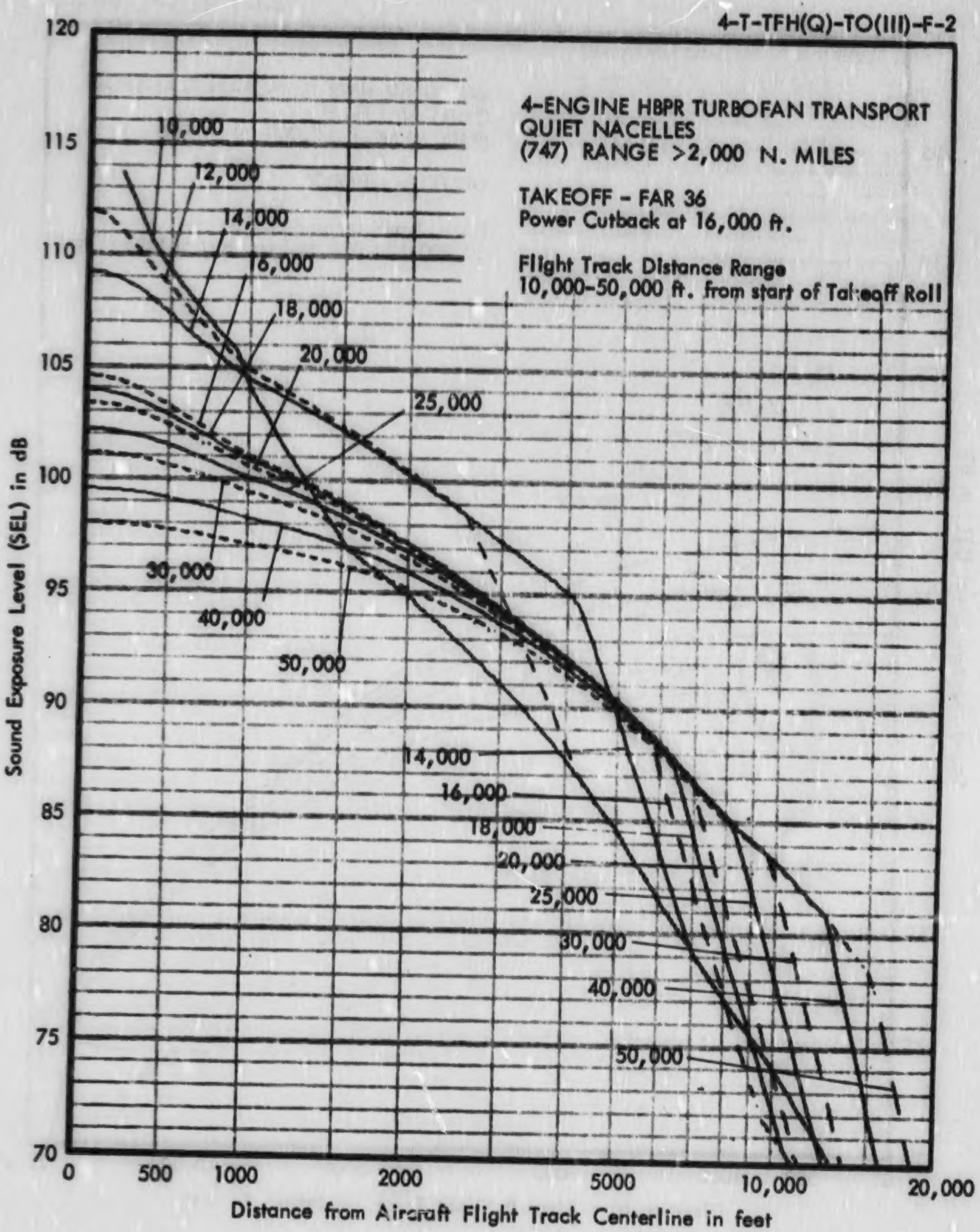

4-T-TFH(Q)-TO(II)-F-2
4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE 1,000-2,000 N. MILES
TAKEOFF - FAR 36
Power Cutback at 12,000 ft.
Flight Track Distance Range
8,000-50,000 ft. from start of Takeoff Roll
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
40,000
50,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
40,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

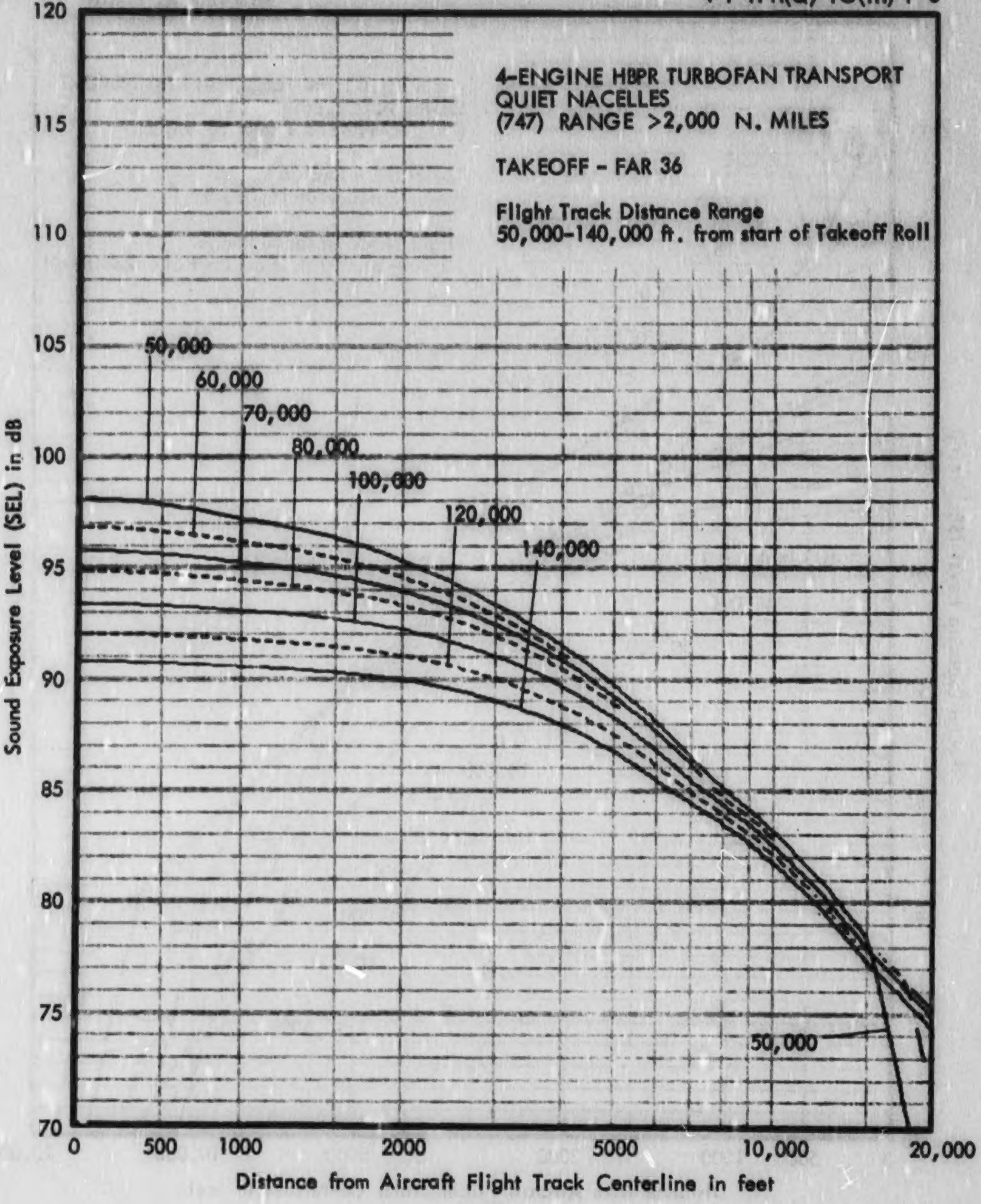
4-T-TFH(Q)-TO(II)-F-3



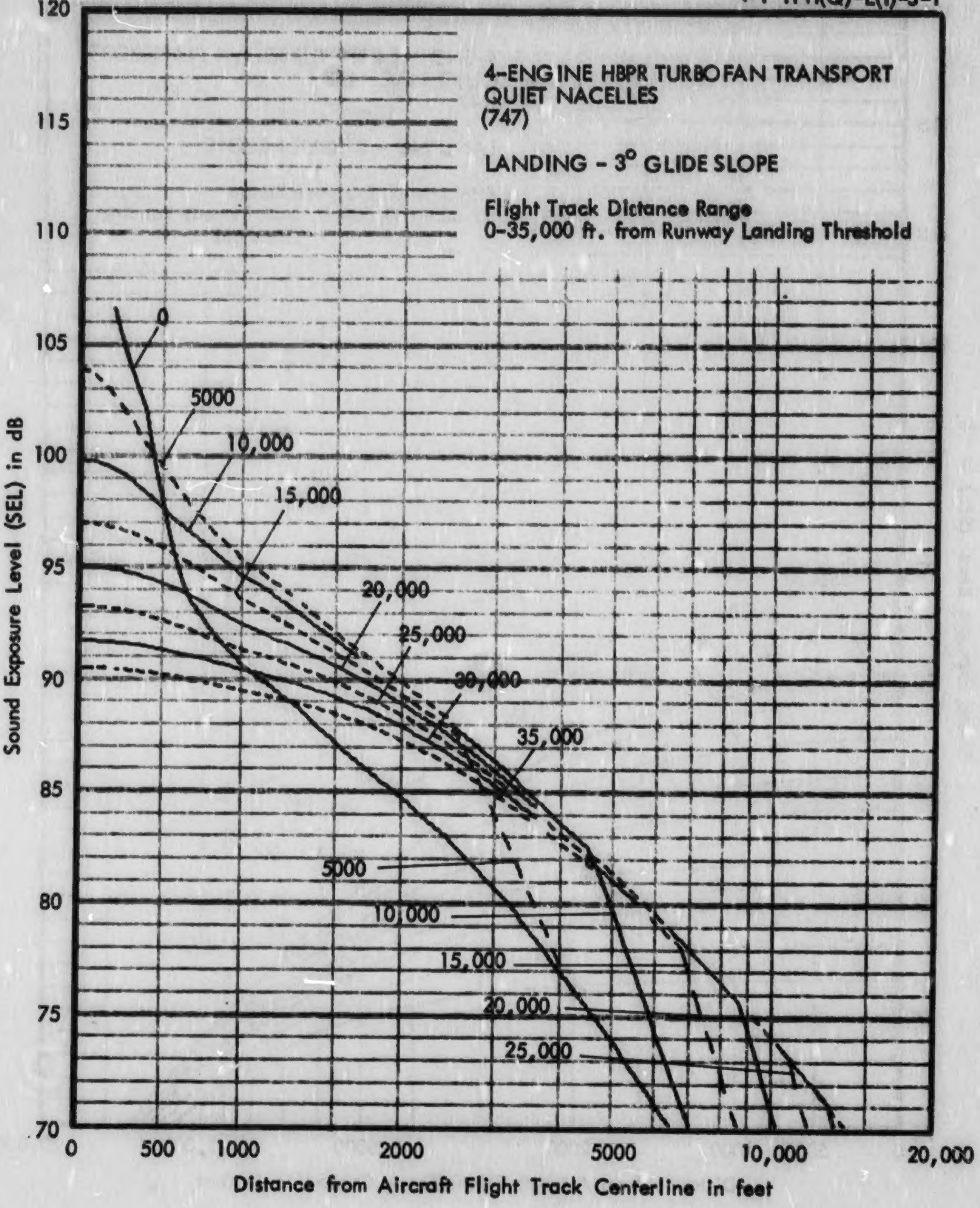

4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE >2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
10,000
0
2000
4000
6000
8000
10,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

4-T-TFH(Q)-TO(III)-F-2




4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747) RANGE >2,000 N. MILES
TAKEOFF - FAR 36
Flight Track Distance Range
50,000-140,000 ft. from start of Takeoff Roll
50,000
60,000
70,000
80,000
100,000
120,000
140,000
50,000
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet

4-T-TFH(Q)-L(I)-S-1

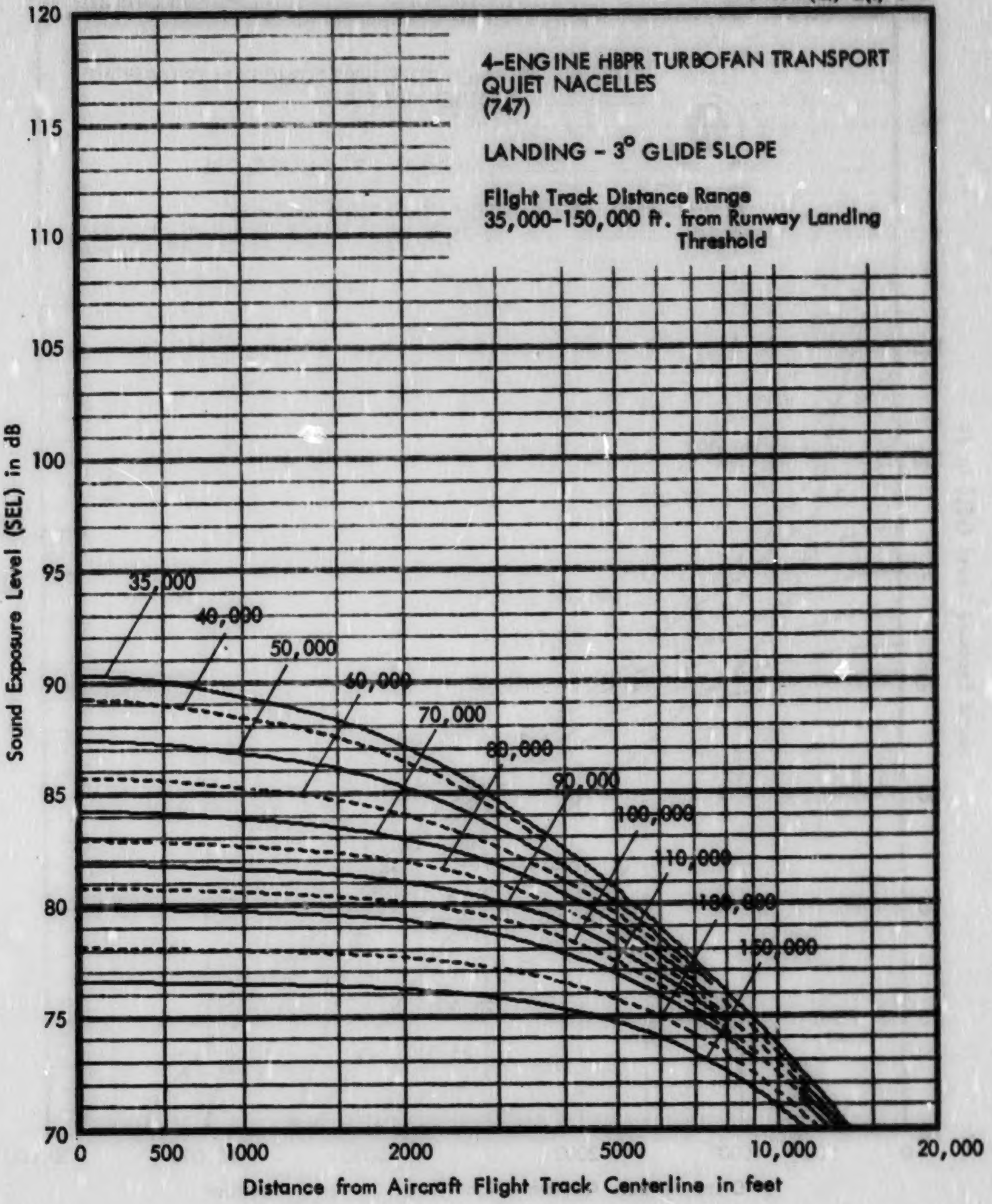


4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747)

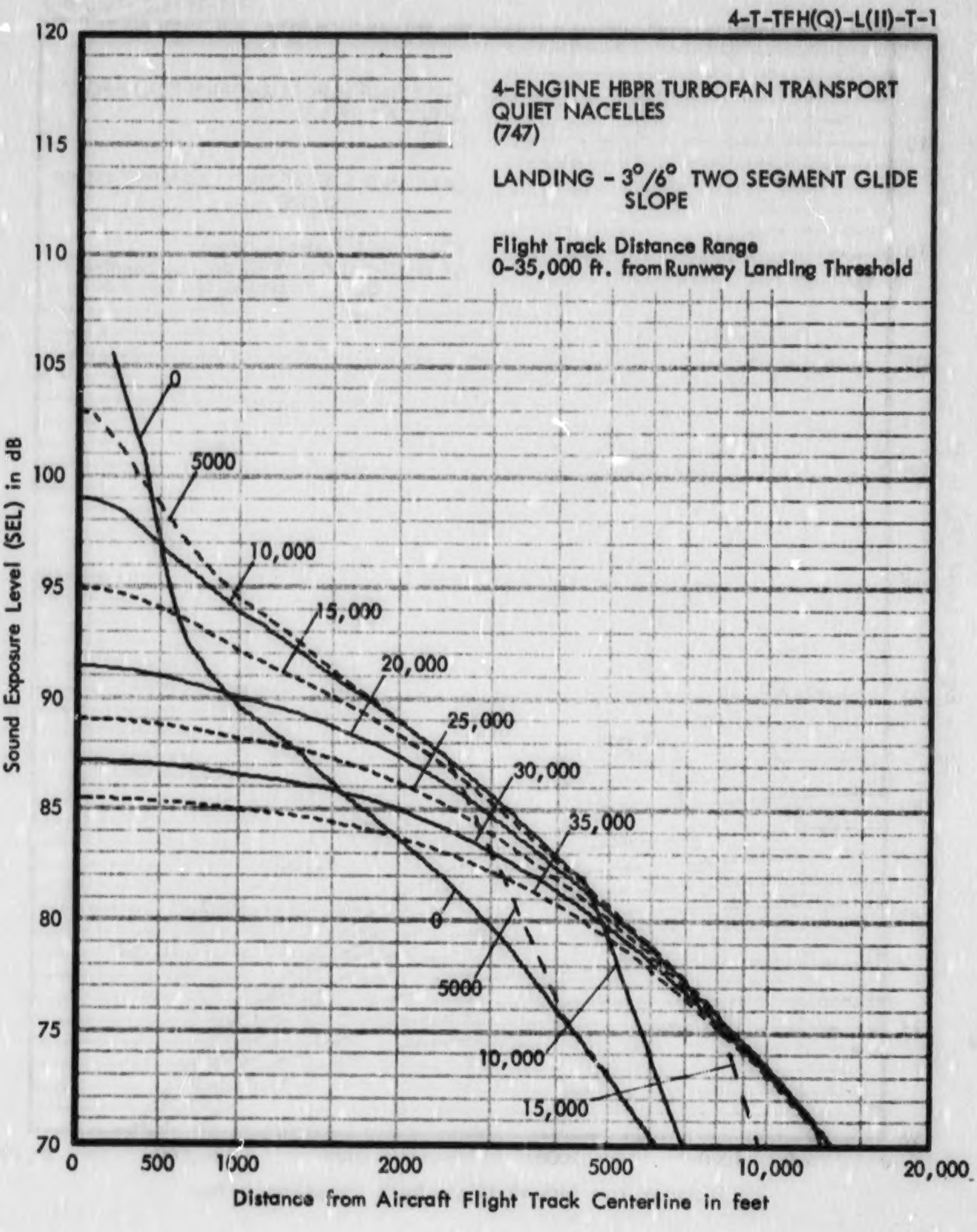
LANDING - 3° GLIDE SLOPE

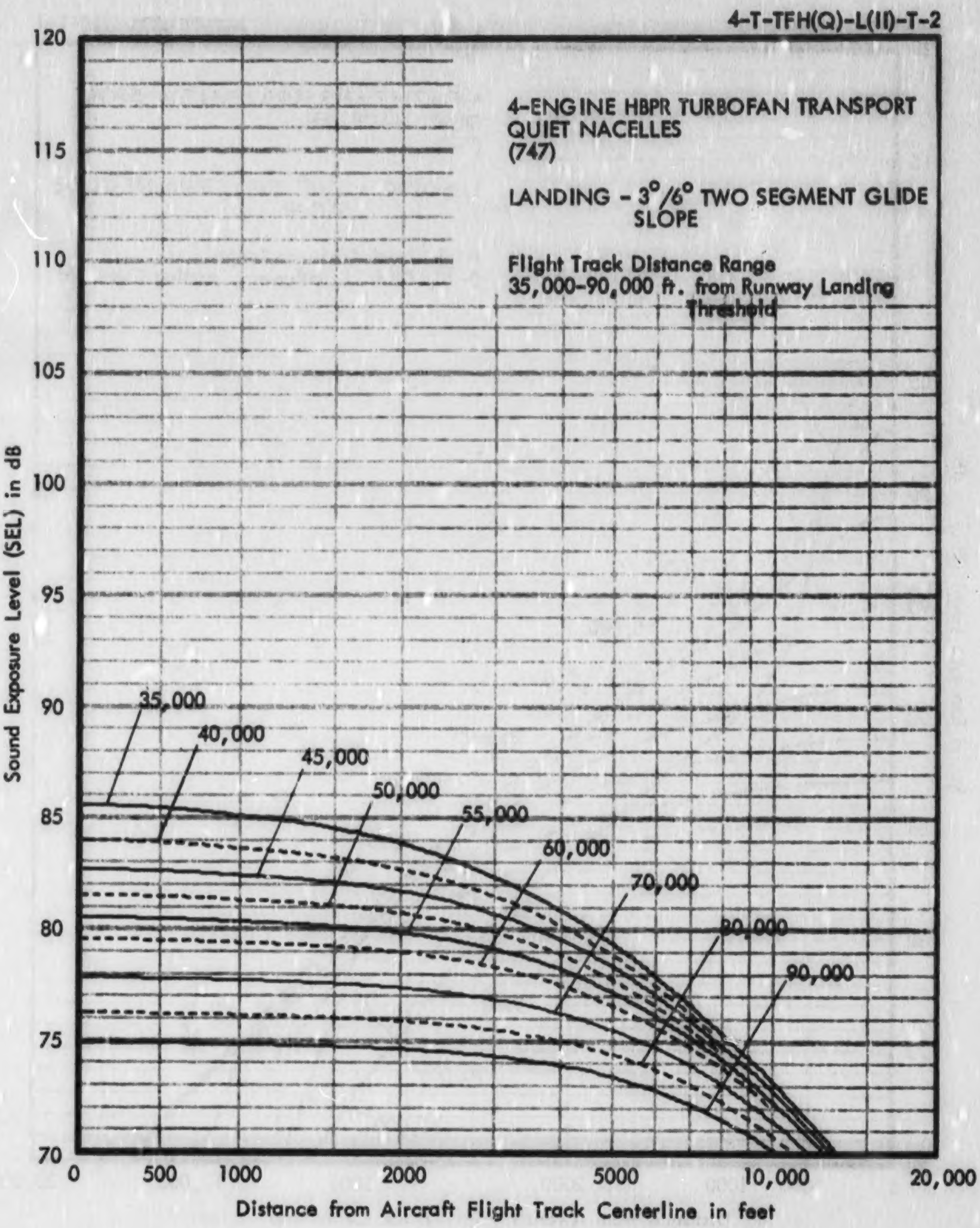
Flight Track Dictance Range
0-35,000 ft. from Runway Landing Threshold

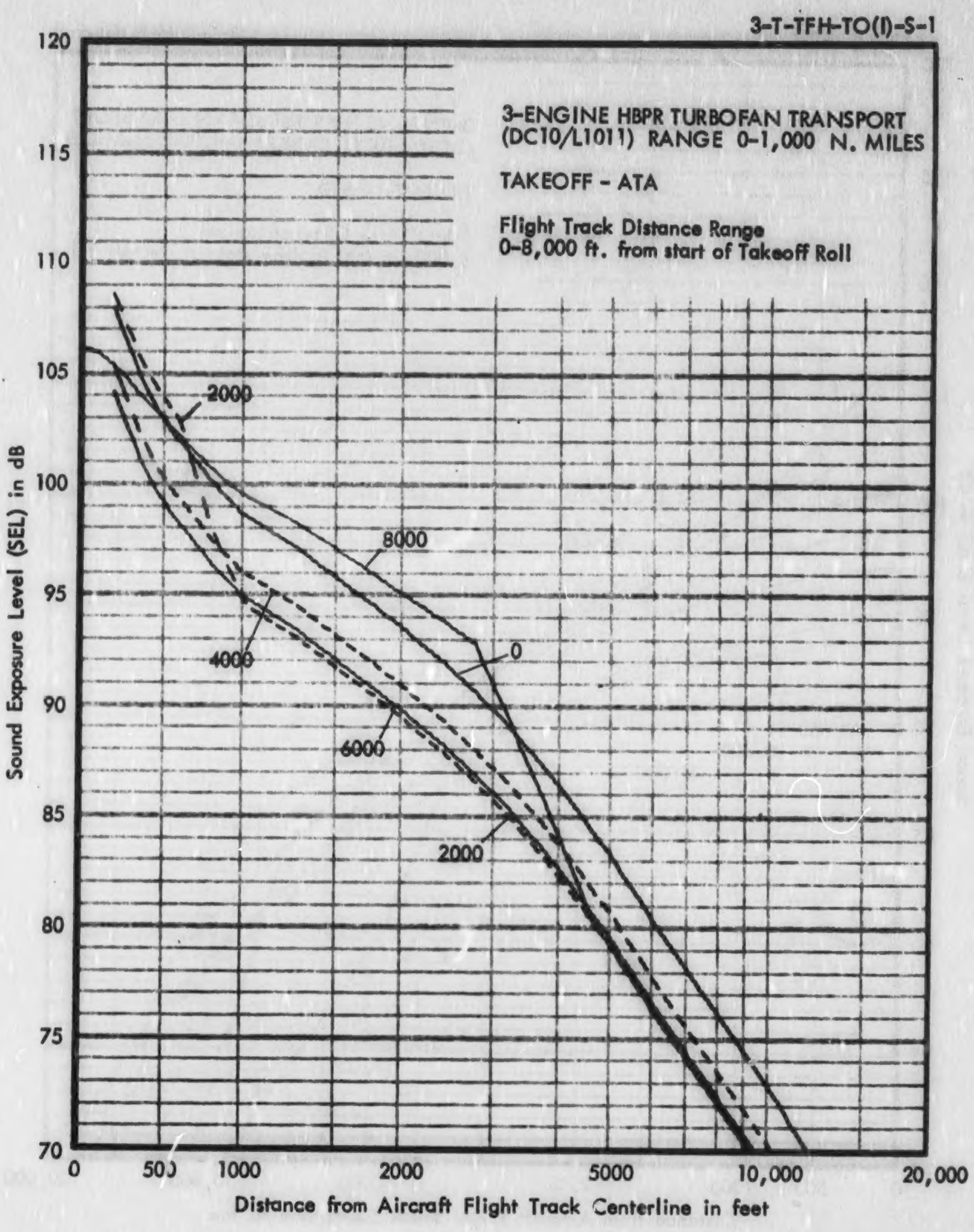
4-T-TFH(Q)-L(I)-S-2

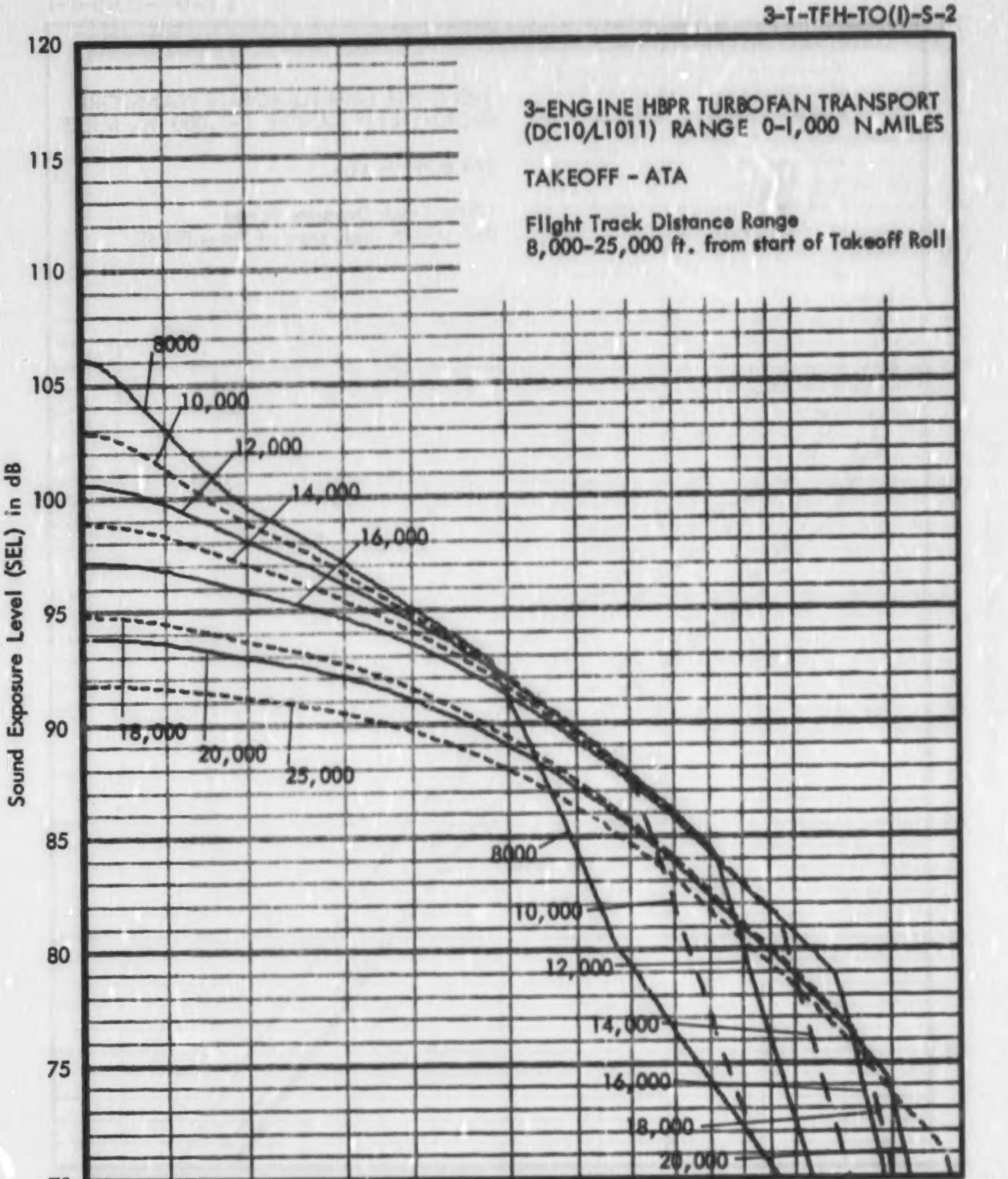

4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
35,000–150,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
130,000
150,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

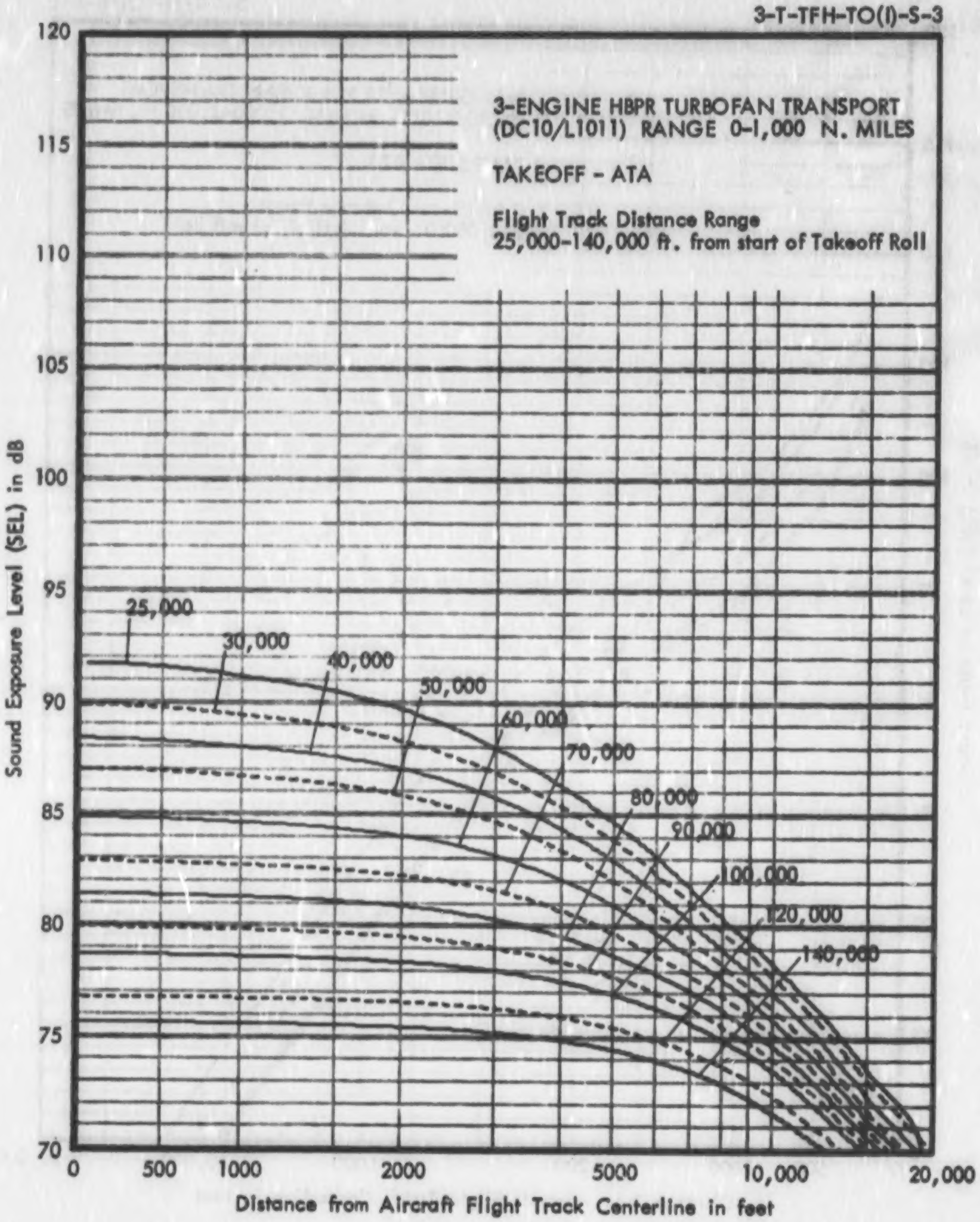
4-T-TFH(Q)-L(II)-T-1

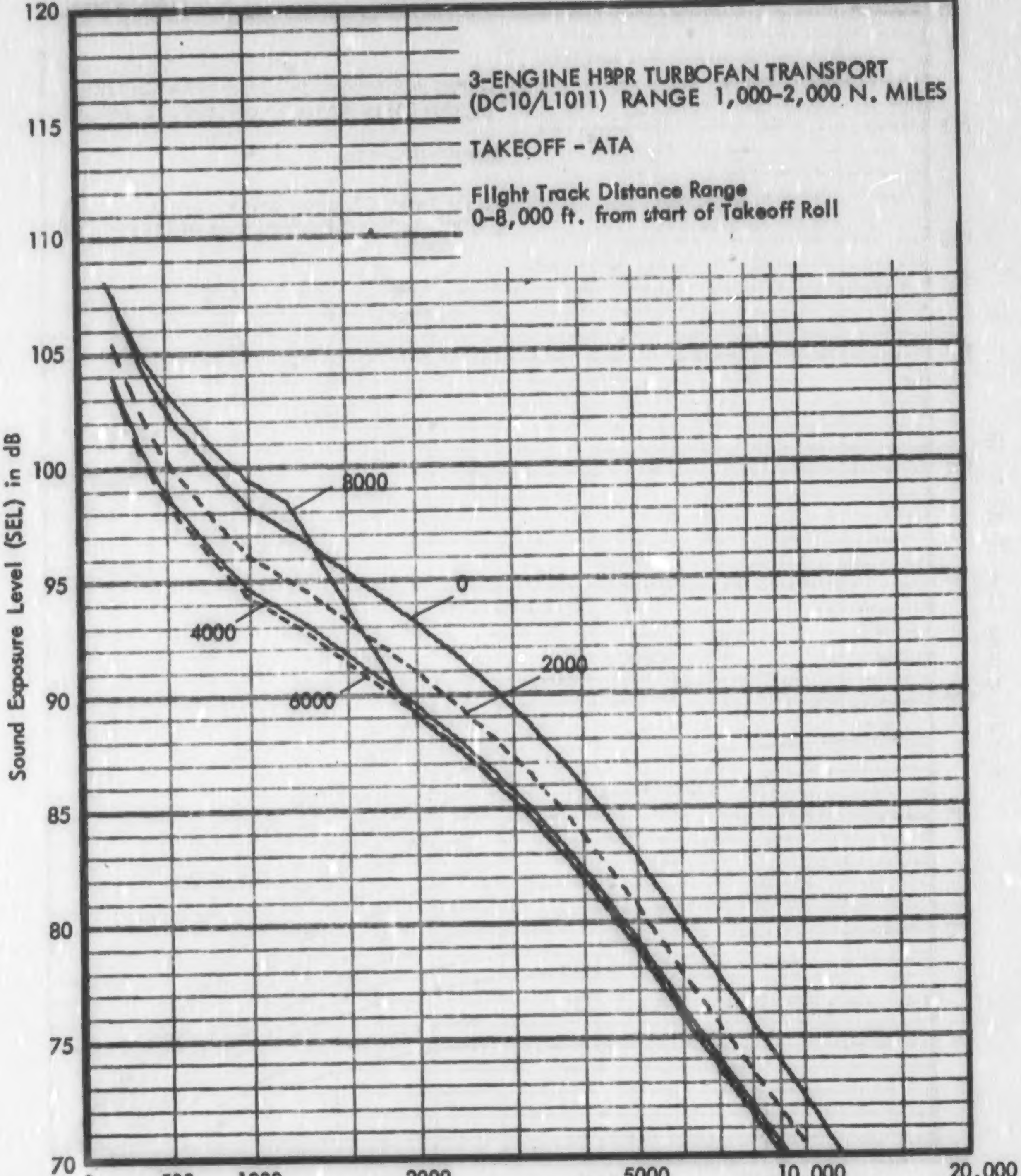



4-ENGINE HBPR TURBOFAN TRANSPORT
QUIET NACELLES
(747)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range
35,000-90,000 ft. from Runway Landing Threshold
35,000
40,000
45,000
50,000
55,000
60,000
70,000
80,000
90,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

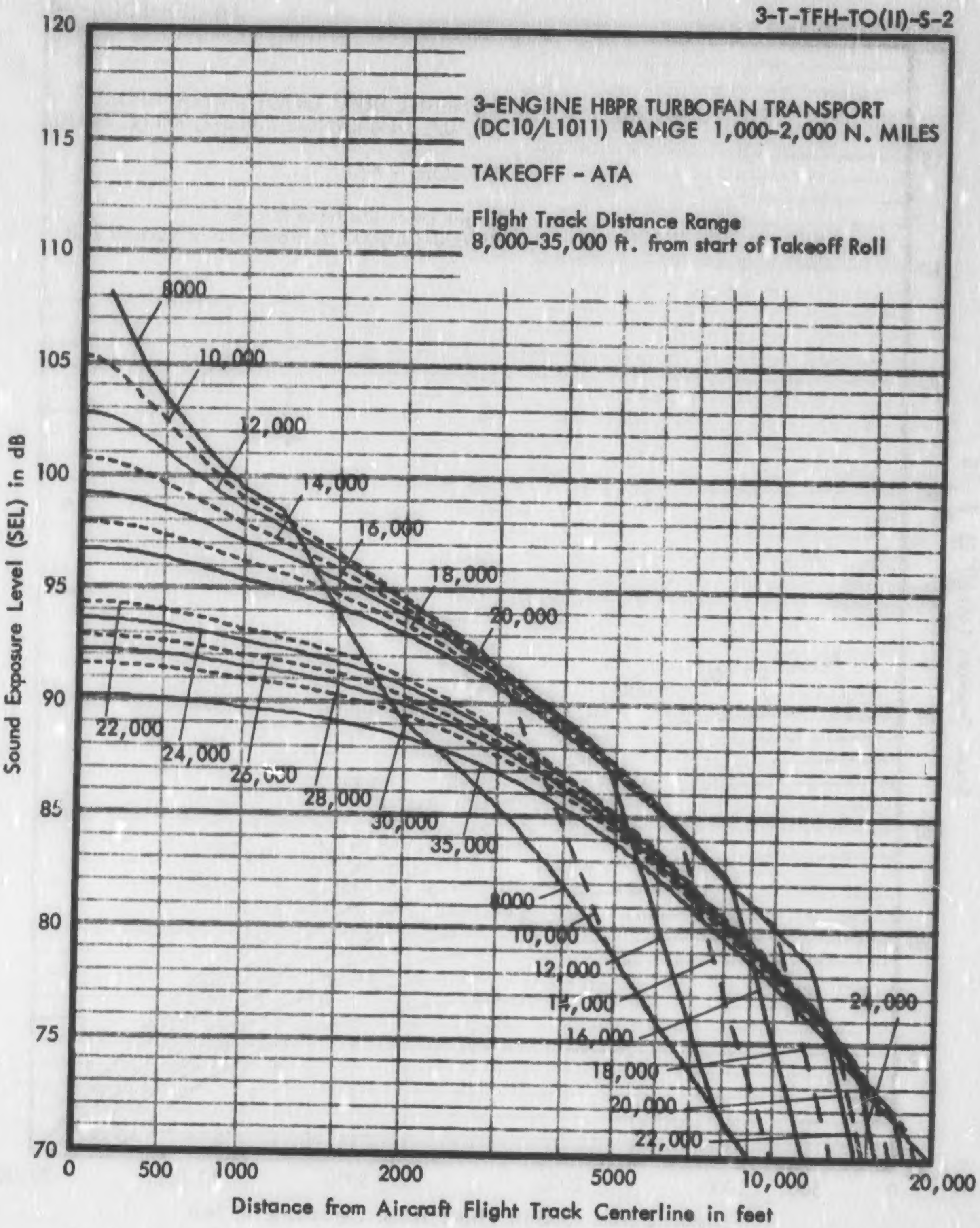

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
2000
8000
0
4000
6000
2000

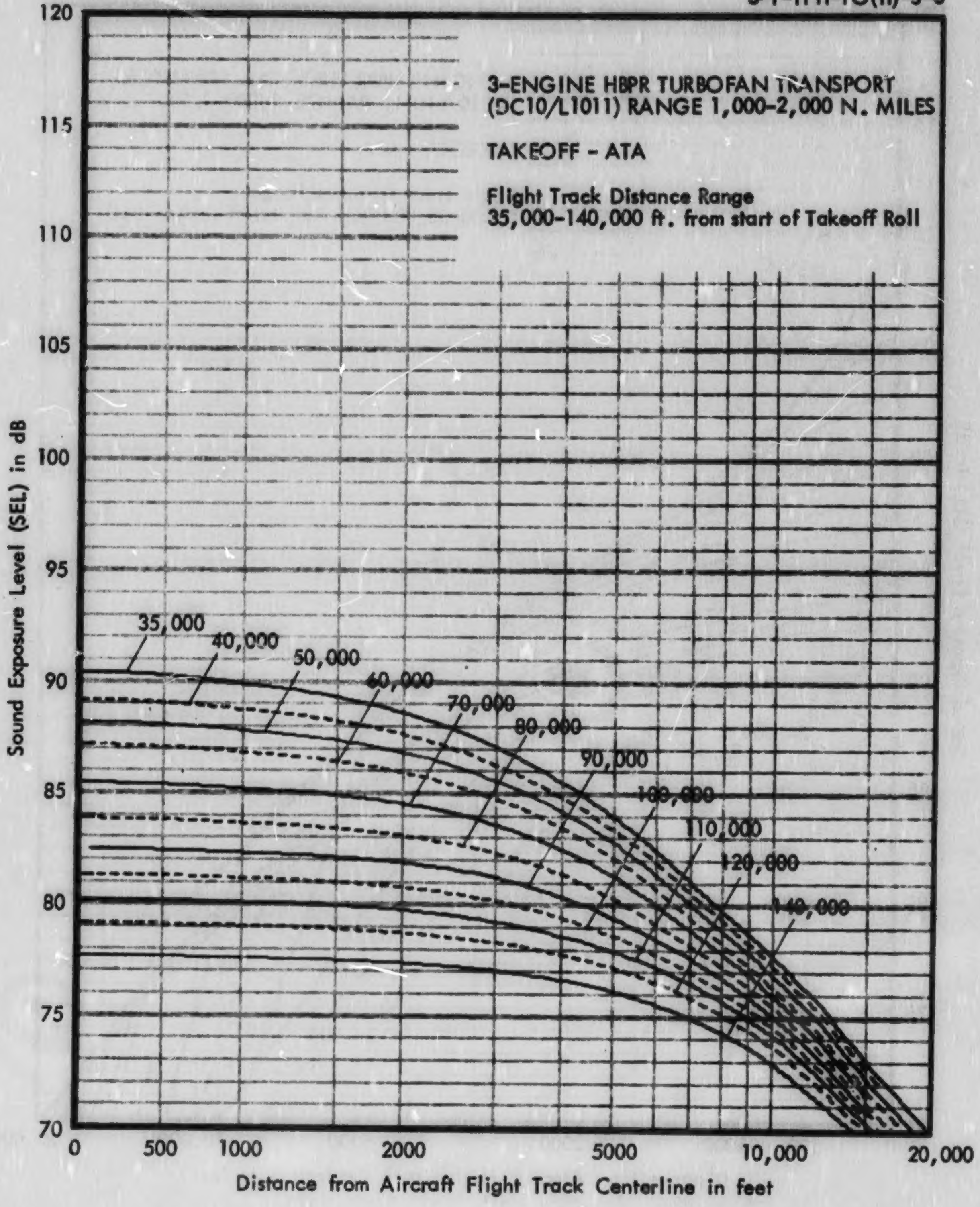

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N.MILES
TAKEOFF - ATA
Flight Track Distance Range
8,000-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
8000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
8000
10,000
12,000
14,000
16,000
18,000
20,000


3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
25,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
25,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

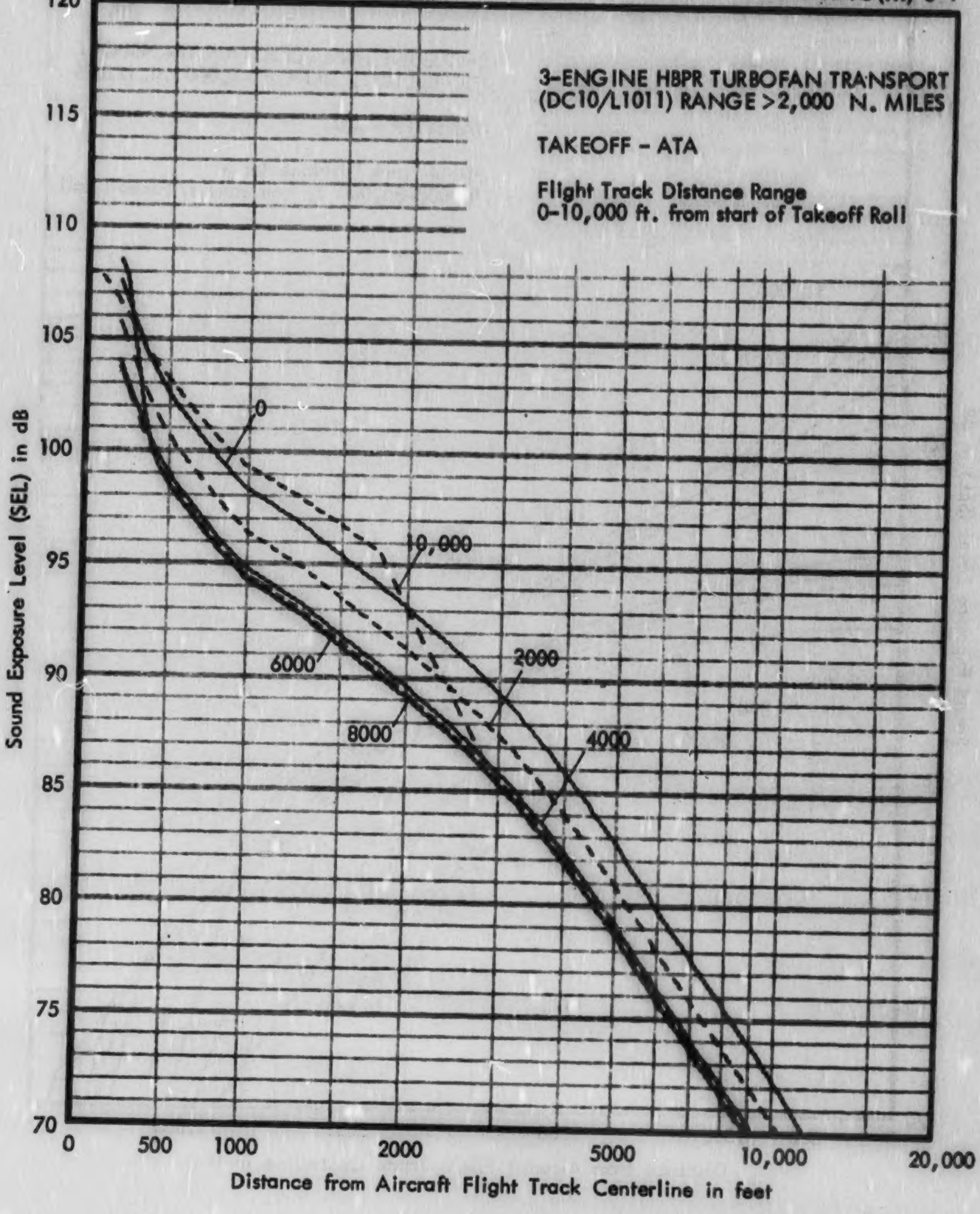

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 1,000-2,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
8000
0
4000
2000
6000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

3-T-TFH-TO(II)-S-2

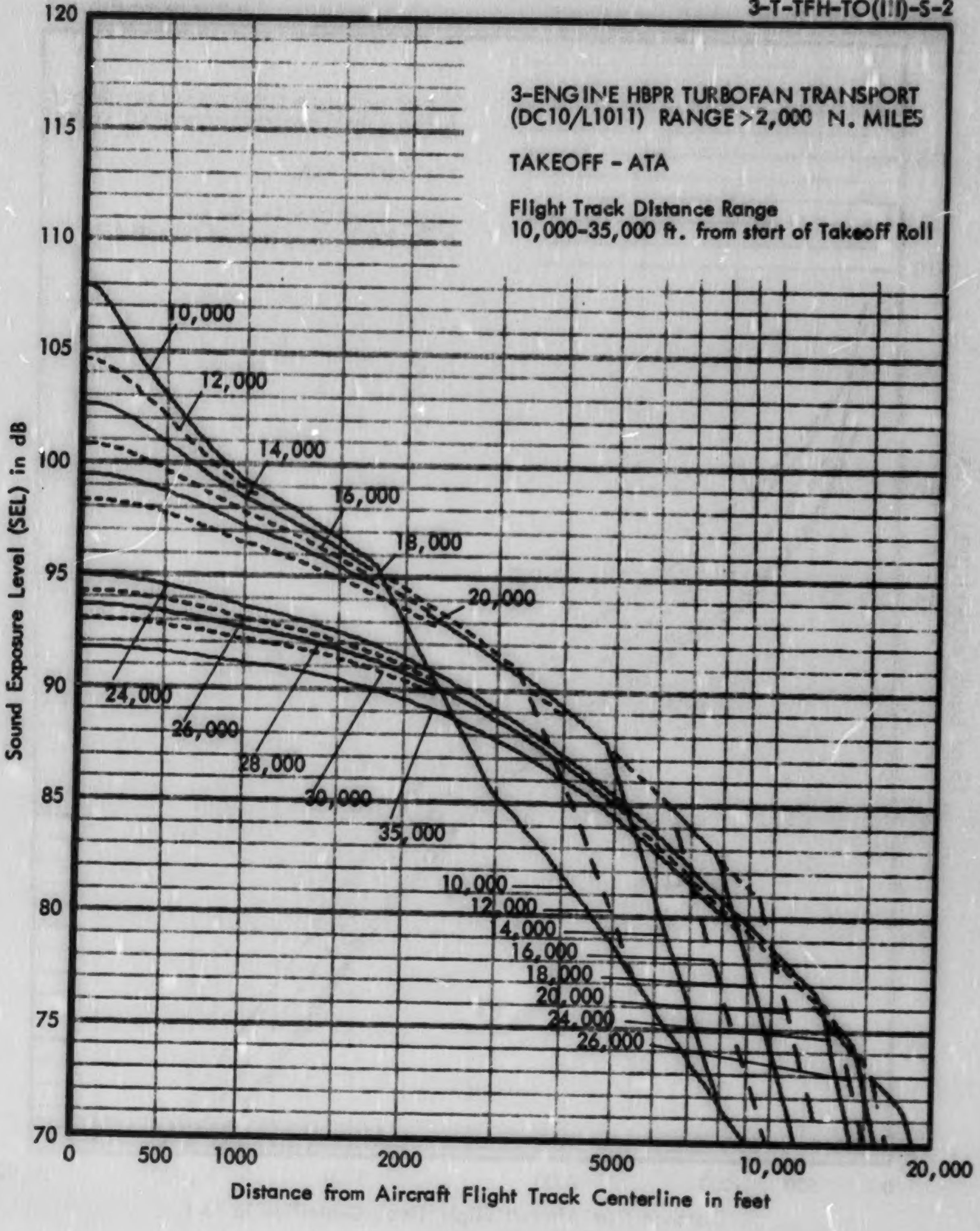


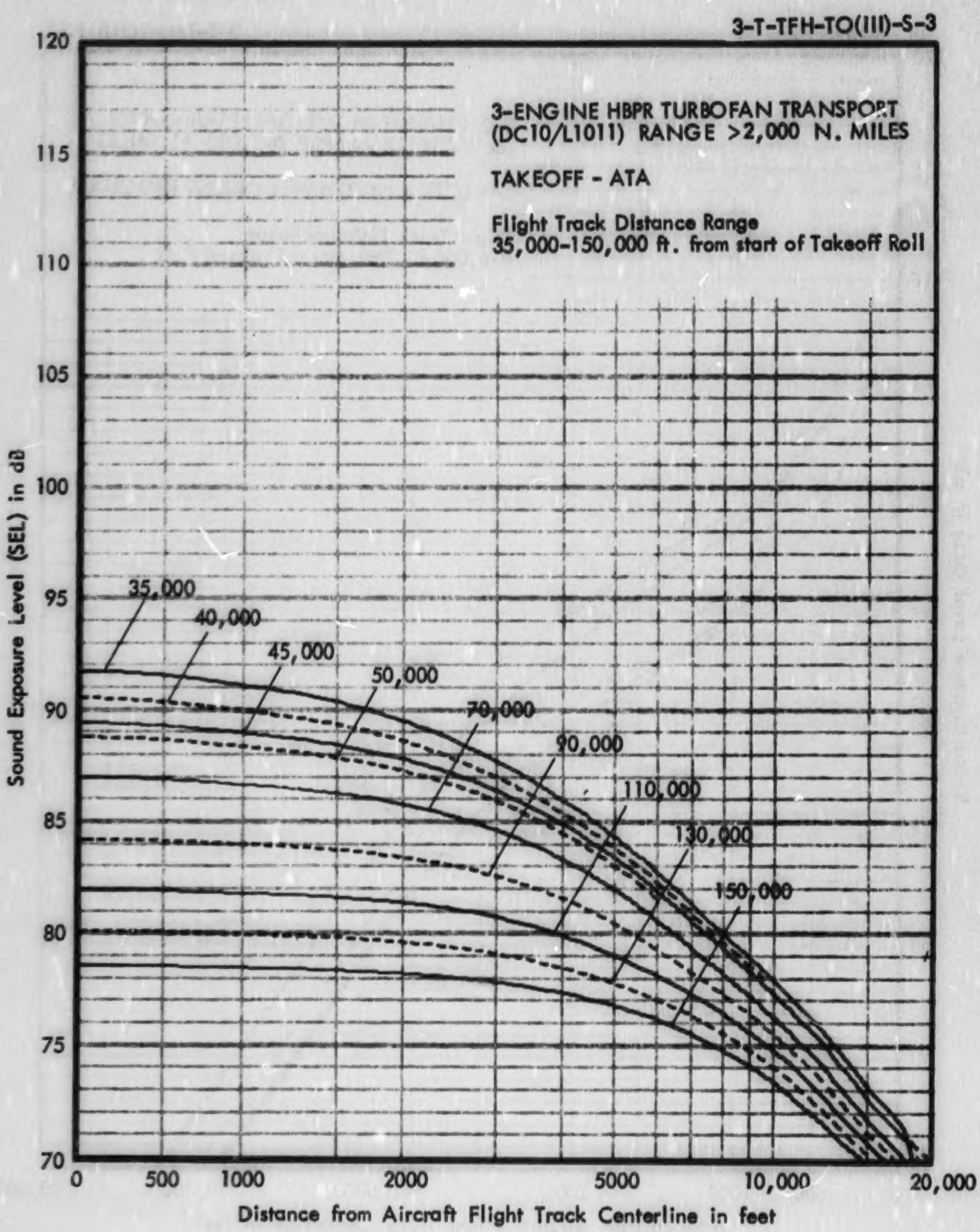

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 1,000-2,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
35,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

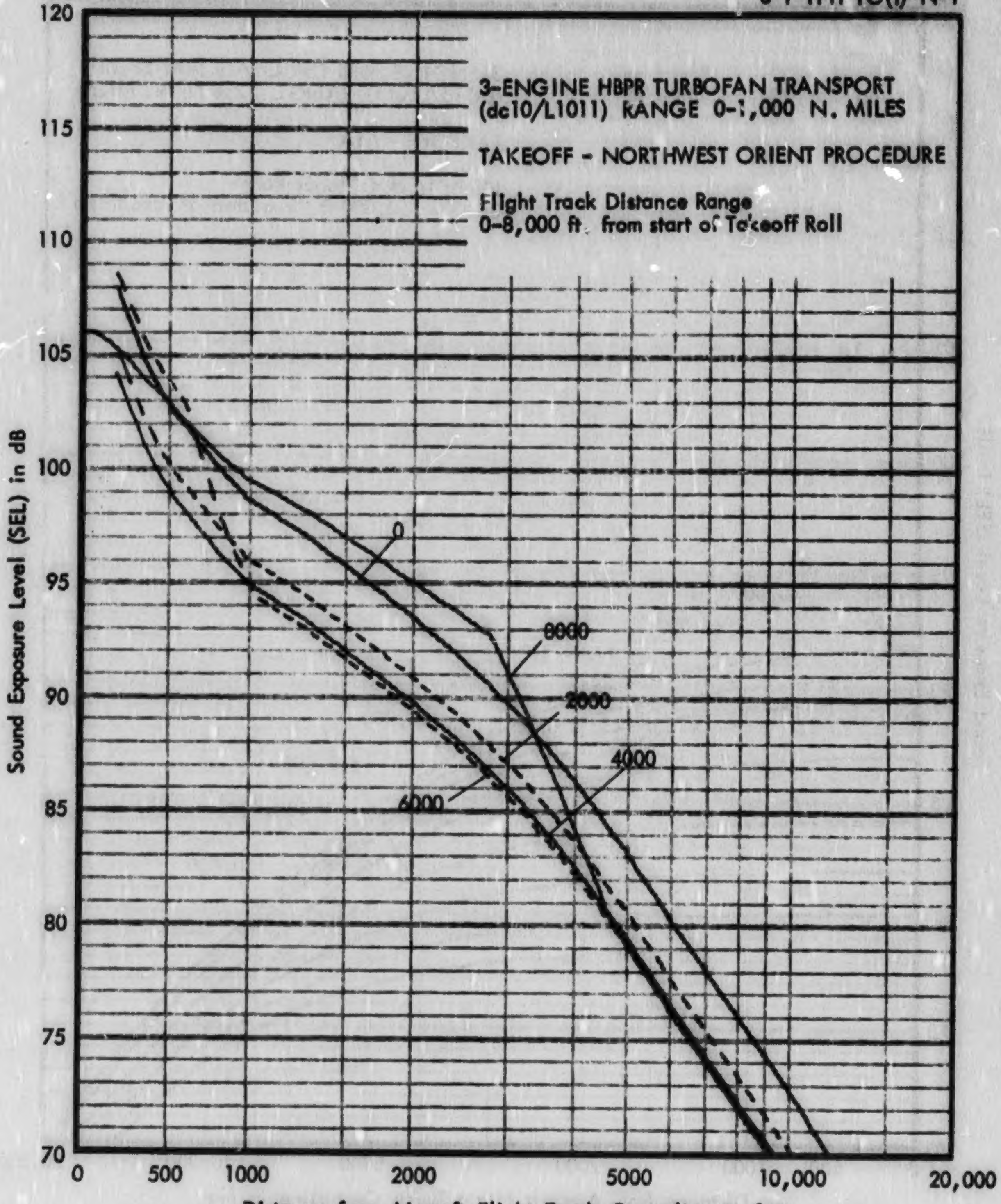
3-T-TFH-TO(III)-S-1



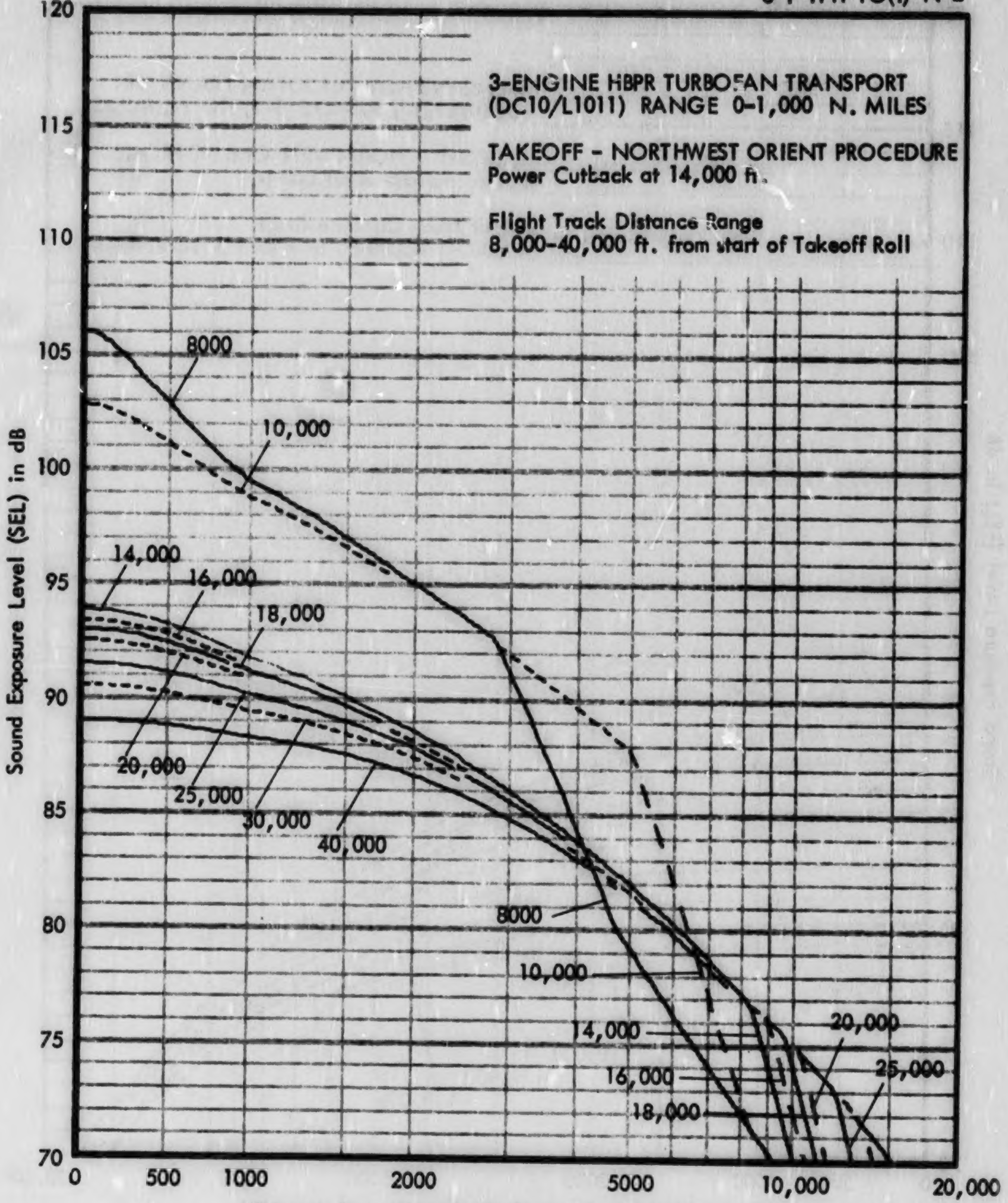
3-T-TFH-TO(III)-S-2



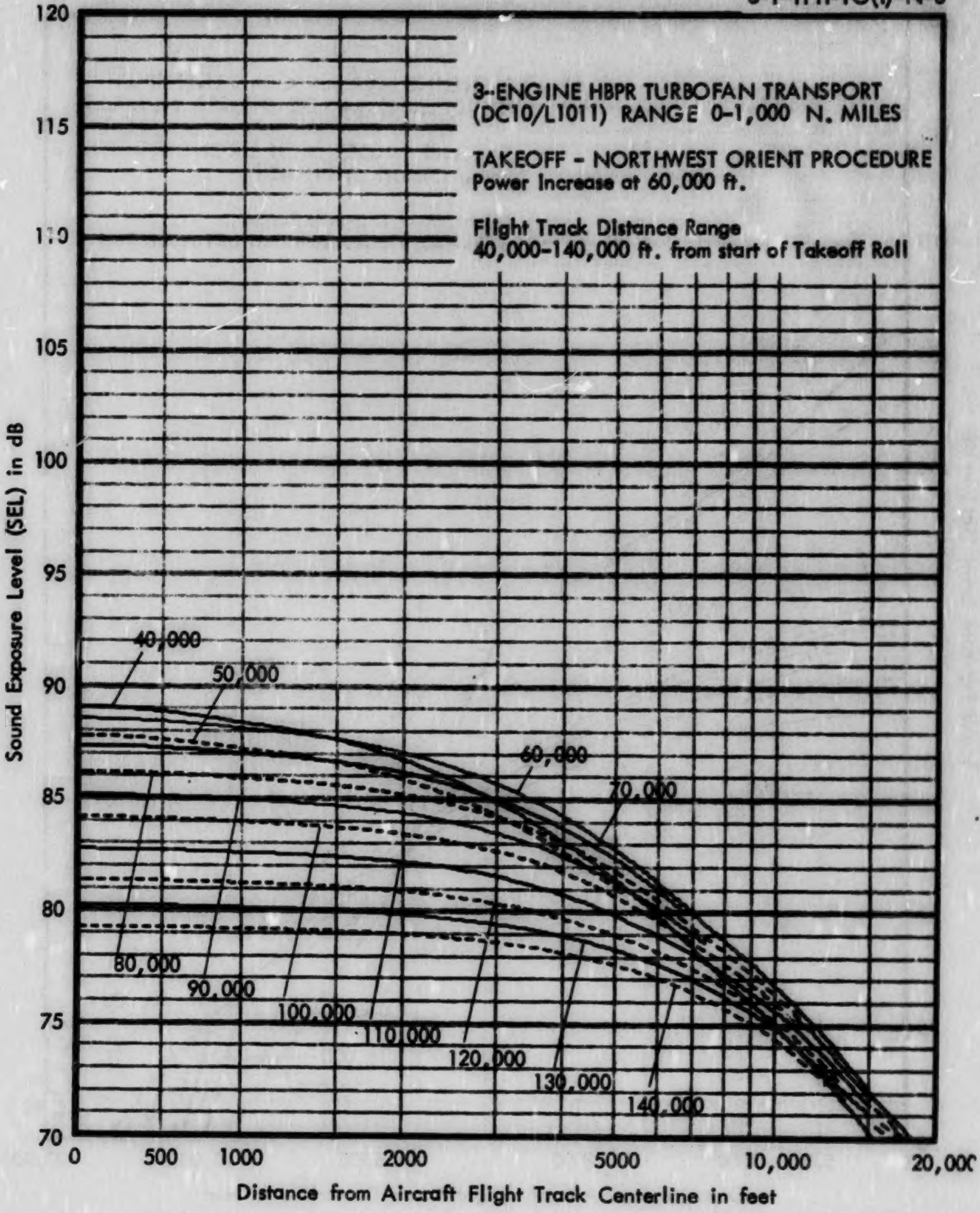

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE >2,000 N. MILES
TAKEOFF - ATA
Flight Track Distance Range
35,000-150,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
35,000
40,000
45,000
50,000
70,000
90,000
110,000
130,000
150,000

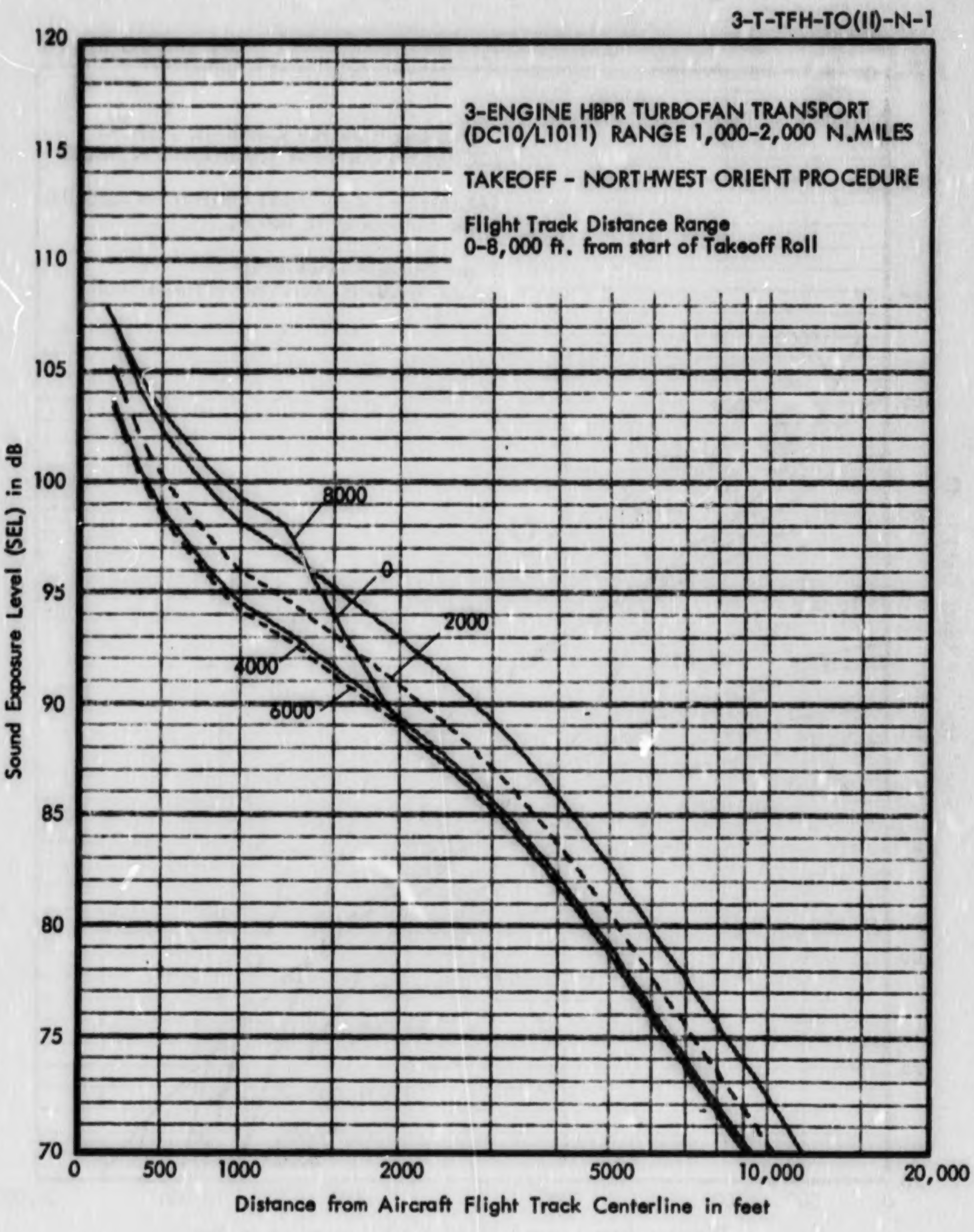

3-ENGINE HBPR TURBOFAN TRANSPORT
(dc10/L1011) RANGE 0-1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
8000
2000
4000
6000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

3-T-TFH-TO(I)-N-2

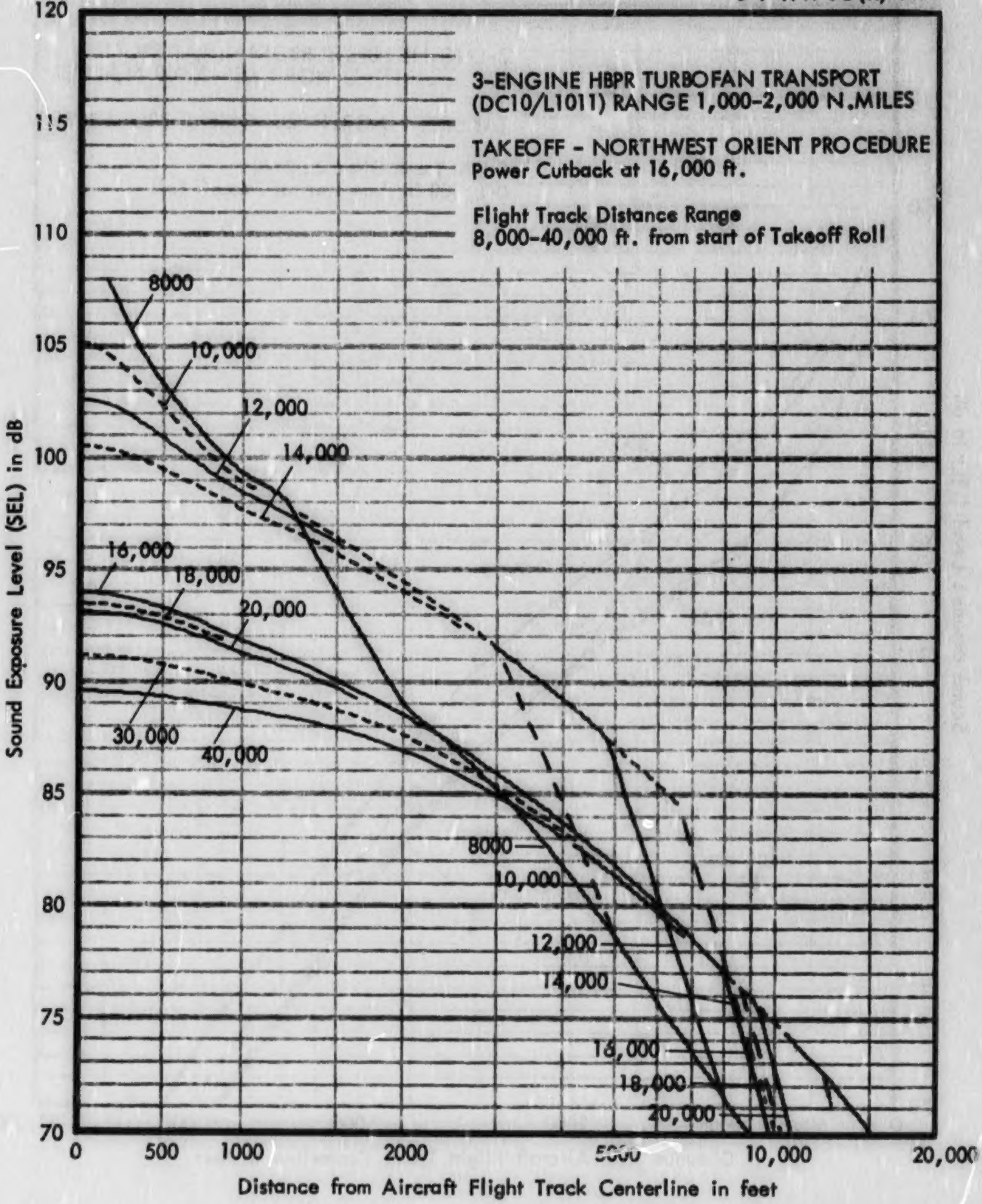

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 14,000 ft.
Flight Track Distance Range
8,000-40,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
8000
10,000
14,000
16,000
18,000
20,000
25,000
30,000
40,000
8000
10,000
14,000
16,000
18,000
20,000
25,000

3-T-TFH-TO(I)-N-3

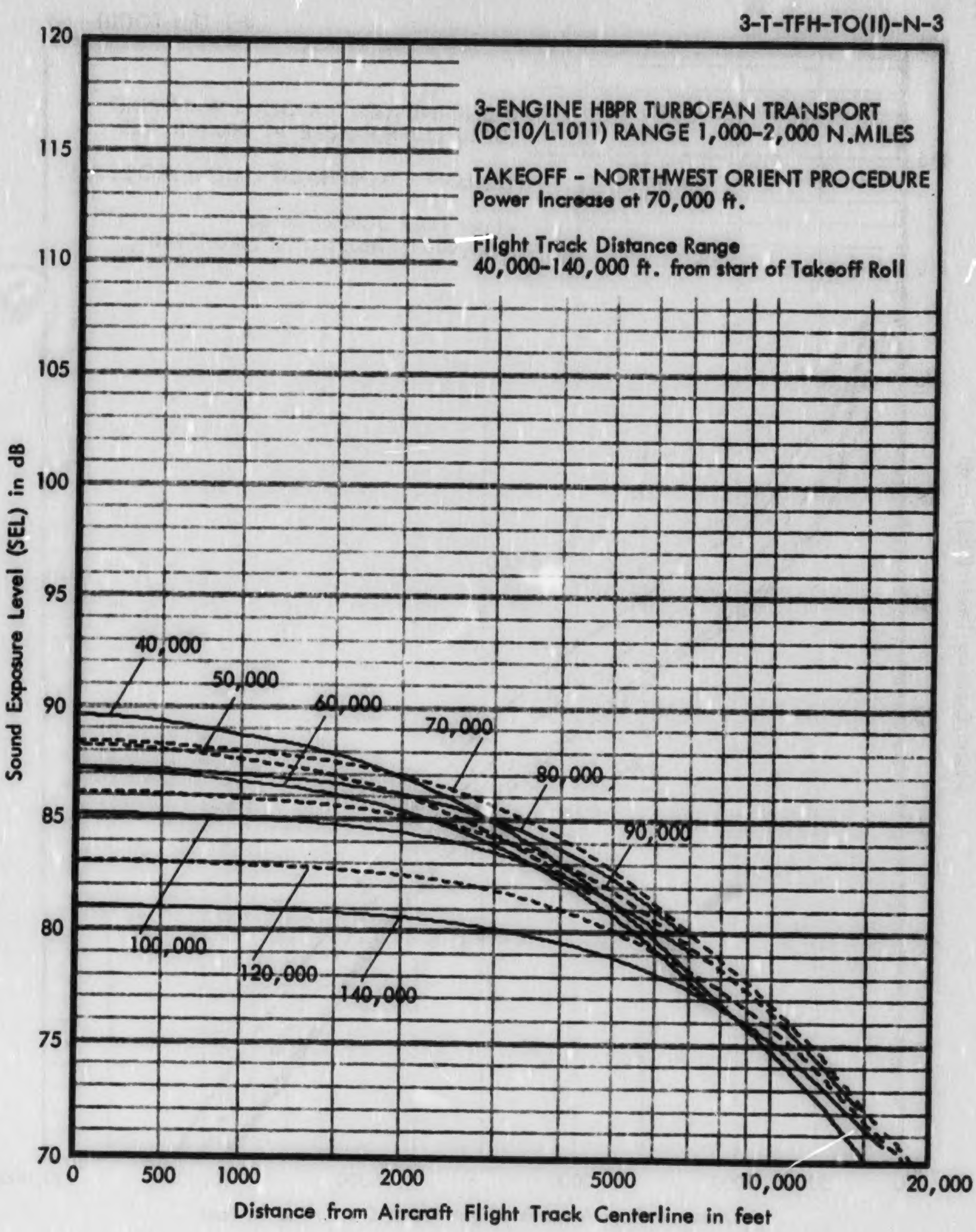

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N. MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 60,000 ft.
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
130,000
140,000
0
500
1000
2000
5000
10,000
20,00
Distance from Aircraft Flight Track Centerline in feet

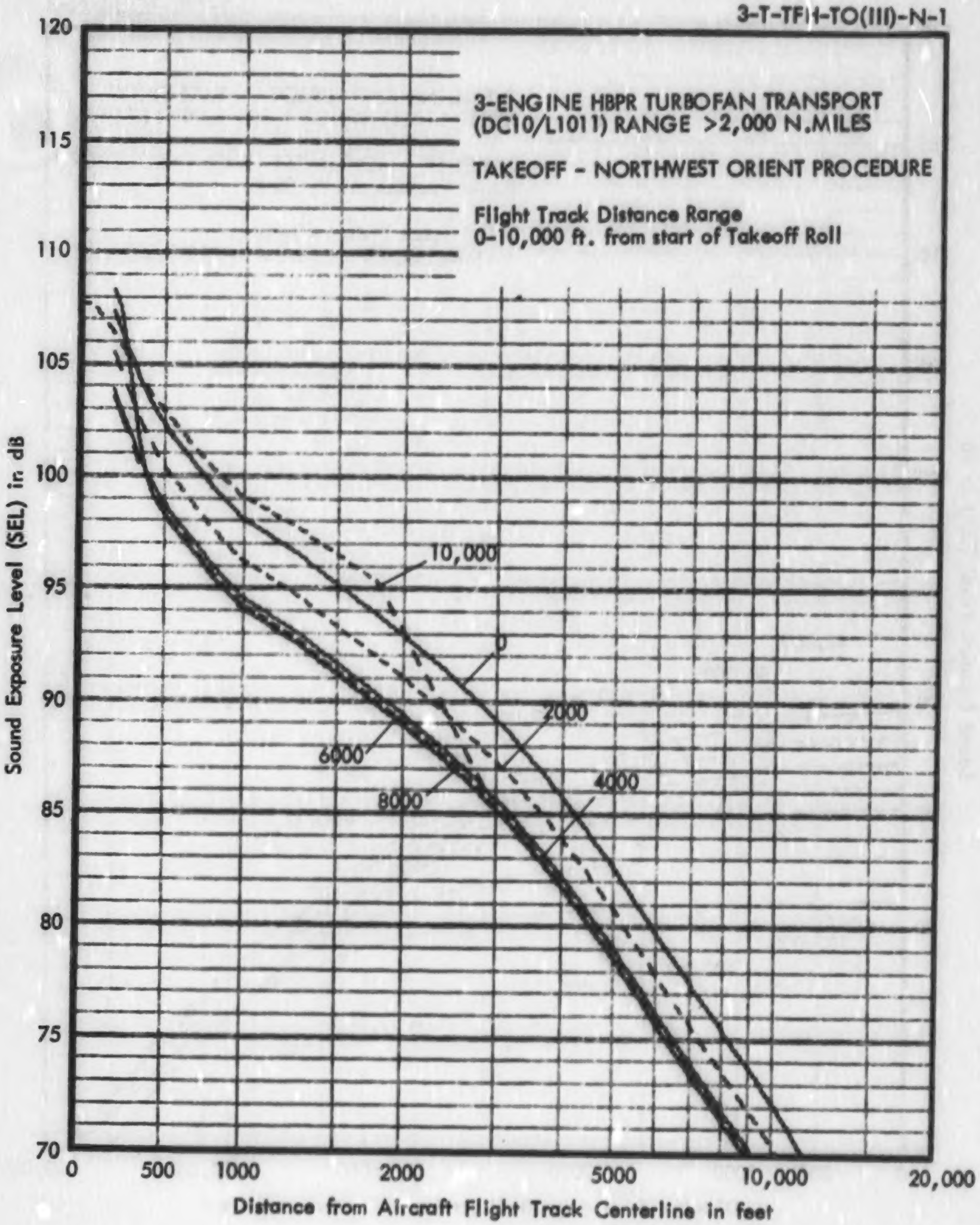

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 1,000-2,000 N.MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
8000
0
2000
4000
6000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

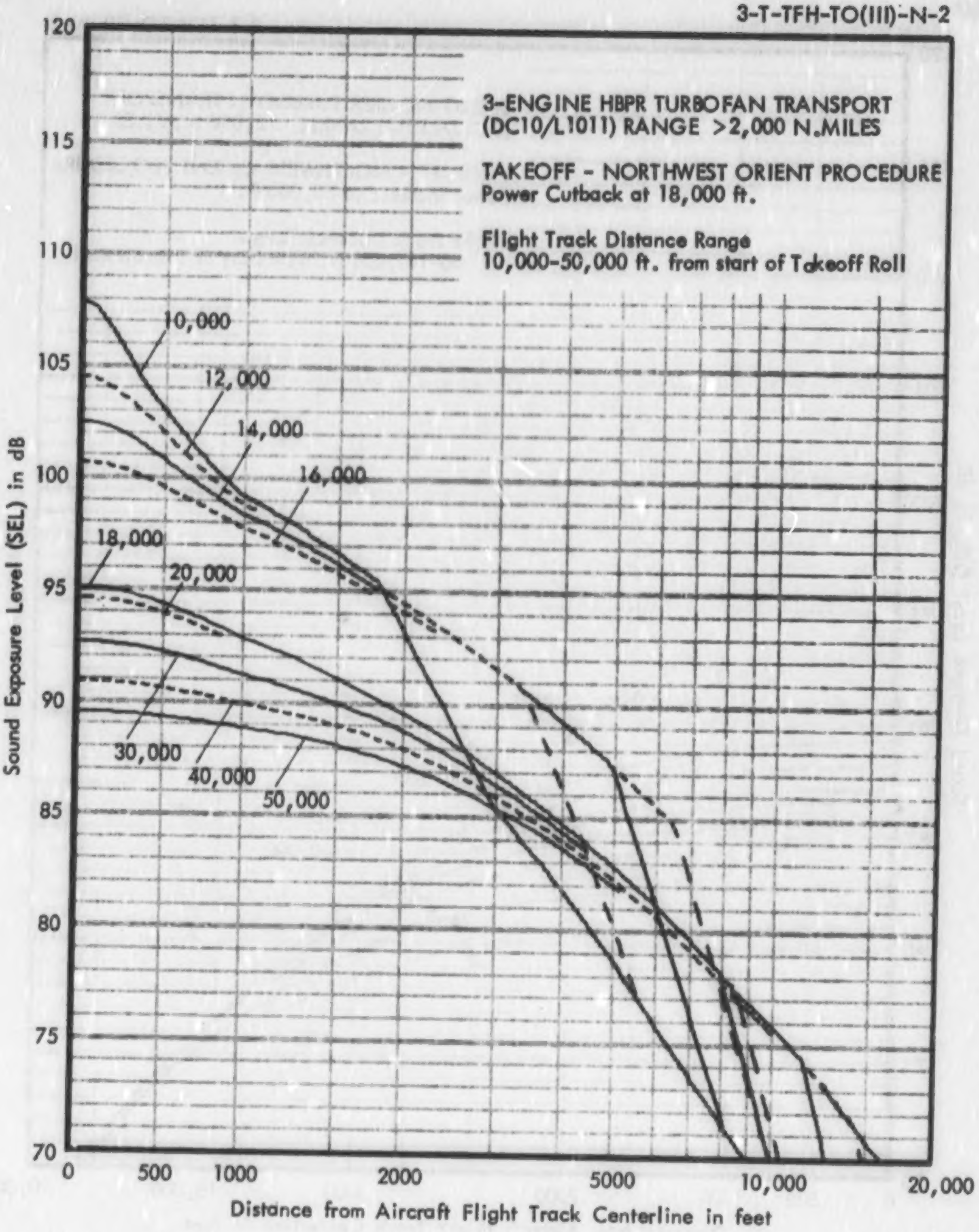
3-T-TFH-TO(II)-N-2



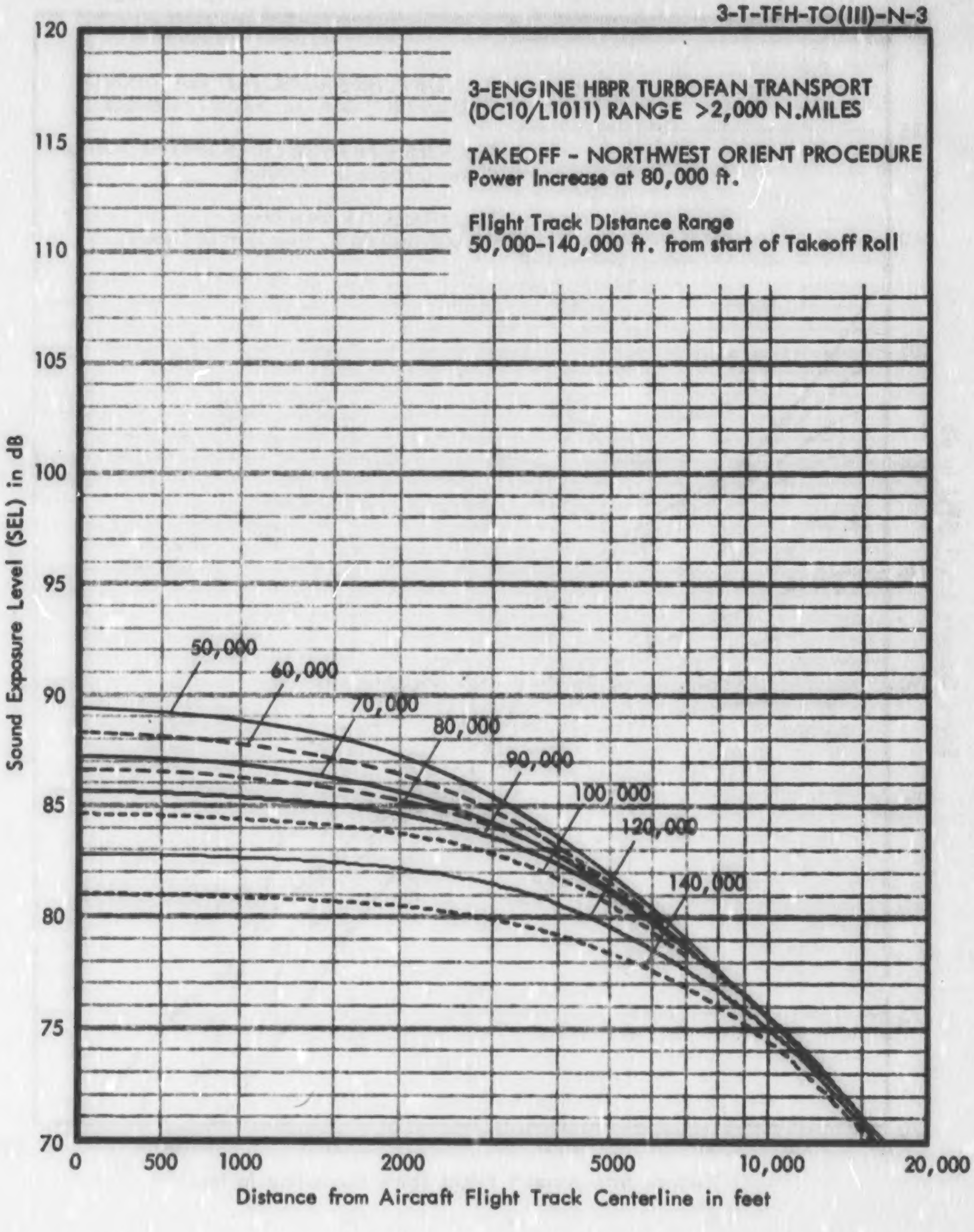
3-T-TFH-TO(II)-N-3




3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE >2,000 N.MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Flight Track Distance Range
0-10,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
10,000
0
2000
4000
6000
8000


3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE >2,000 N.MILES
TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Cutback at 18,000 ft.
Flight Track Distance Range
10,000-50,000 ft. from start of Takeoff Roll
10,000
12,000
14,000
16,000
18,000
20,000
30,000
40,000
50,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

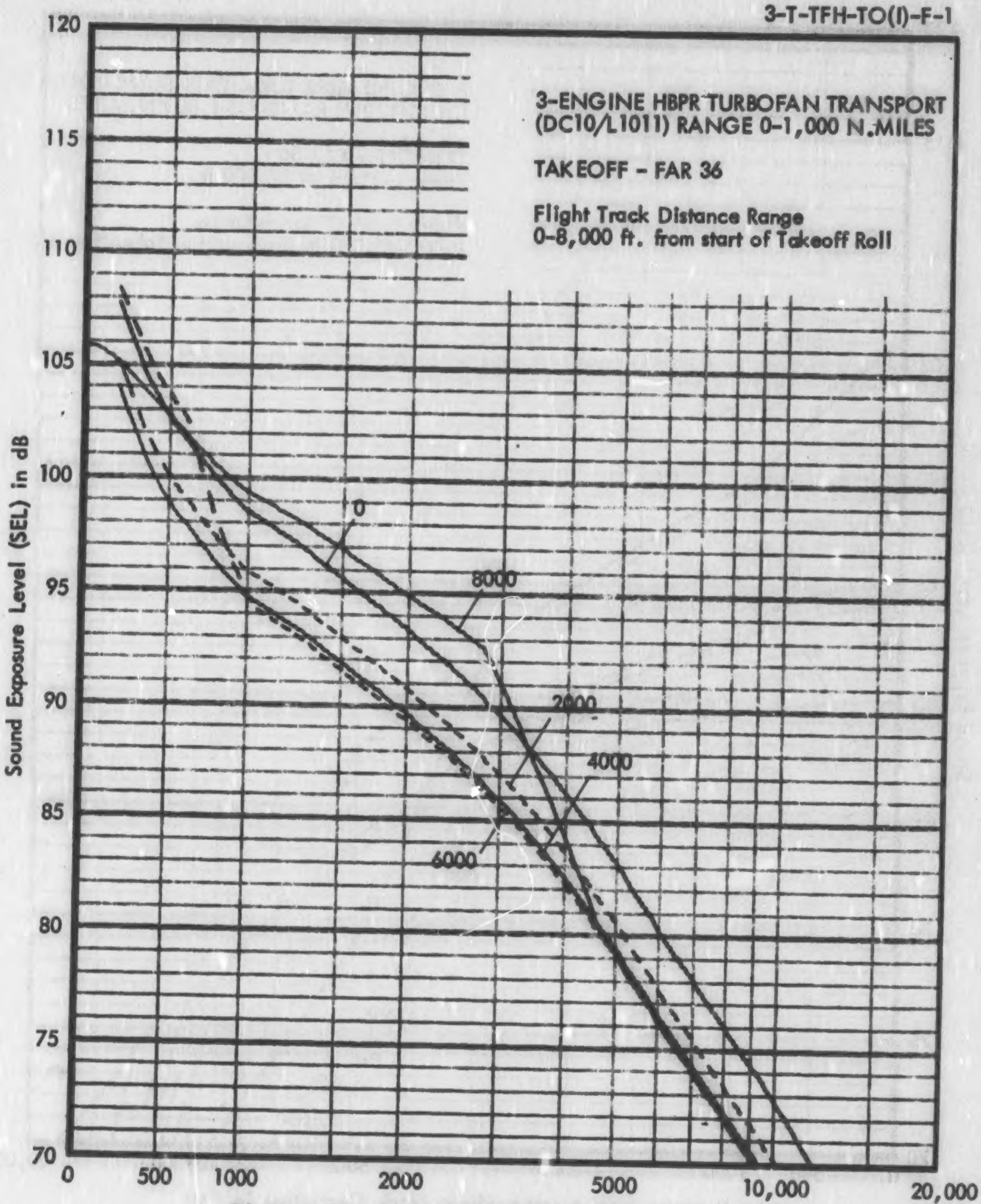
3-T-TFH-TO(III)-N-3



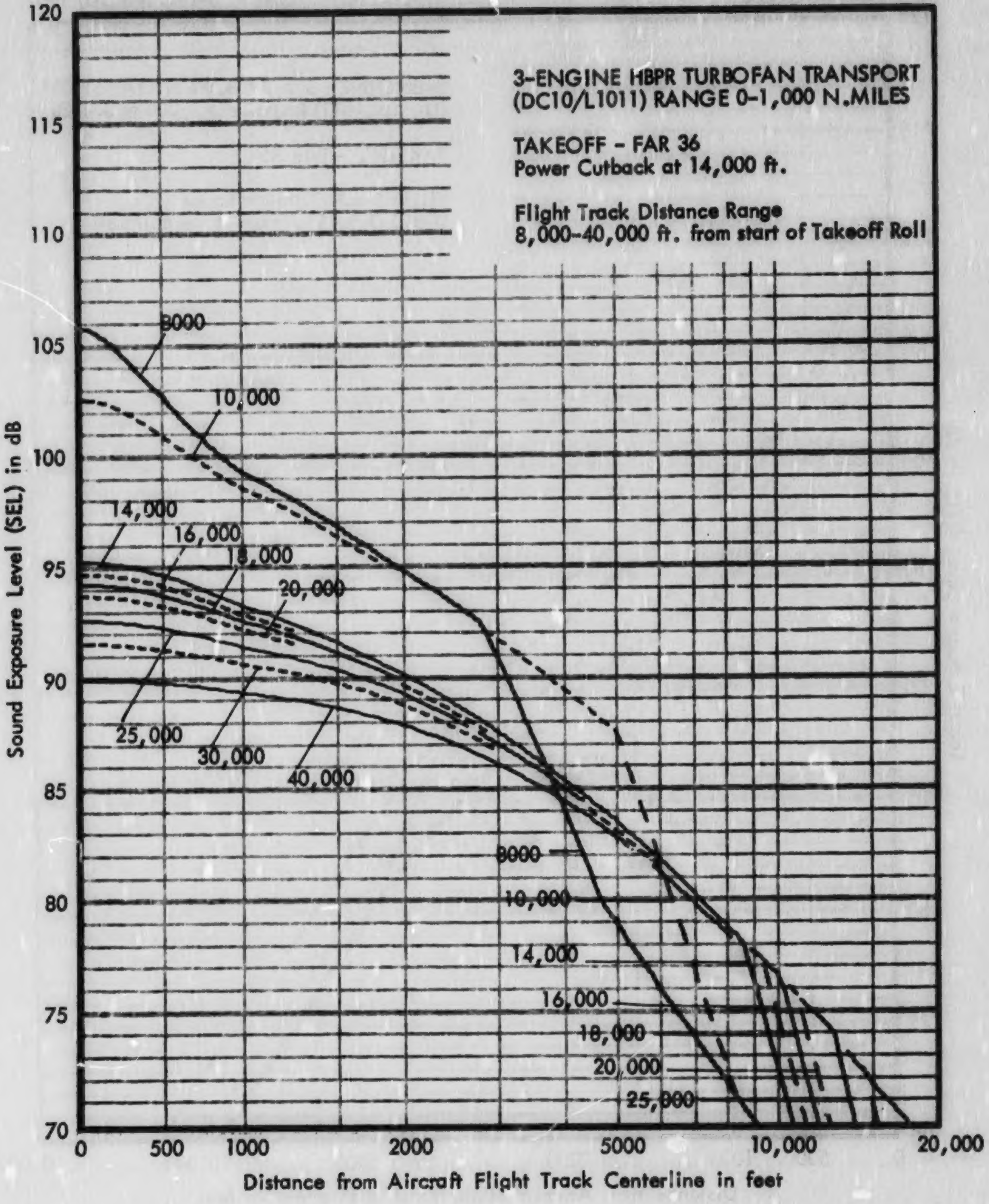
3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE >2,000 N.MILES

TAKEOFF - NORTHWEST ORIENT PROCEDURE
Power Increase at 80,000 ft.

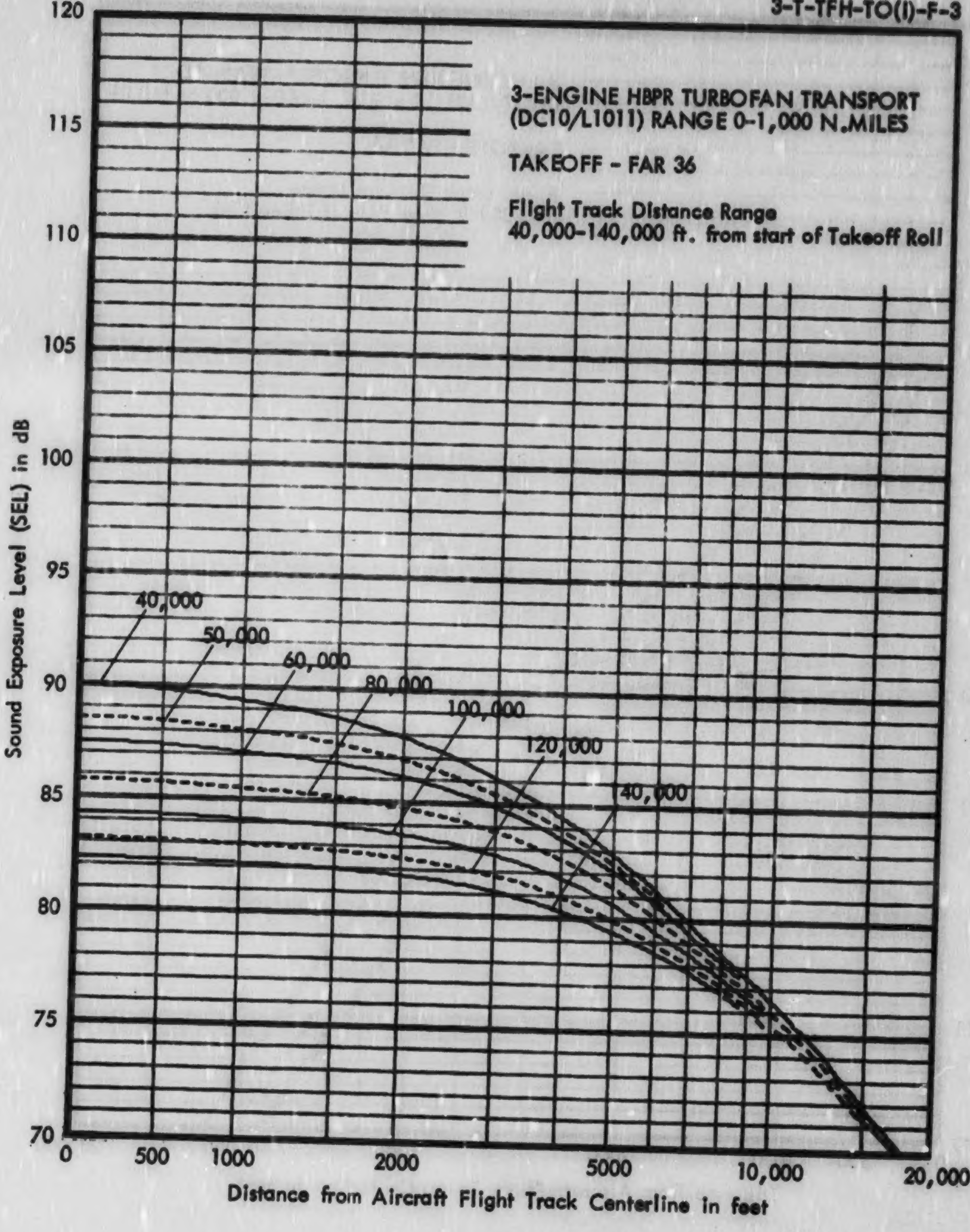
Flight Track Distance Range
50,000-140,000 ft. from start of Takeoff Roll


3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N.MILES
TAKEOFF - FAR 36
Flight Track Distance Range
0-8,000 ft. from start of Takeoff Roll
0
8000
2000
4000
6000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

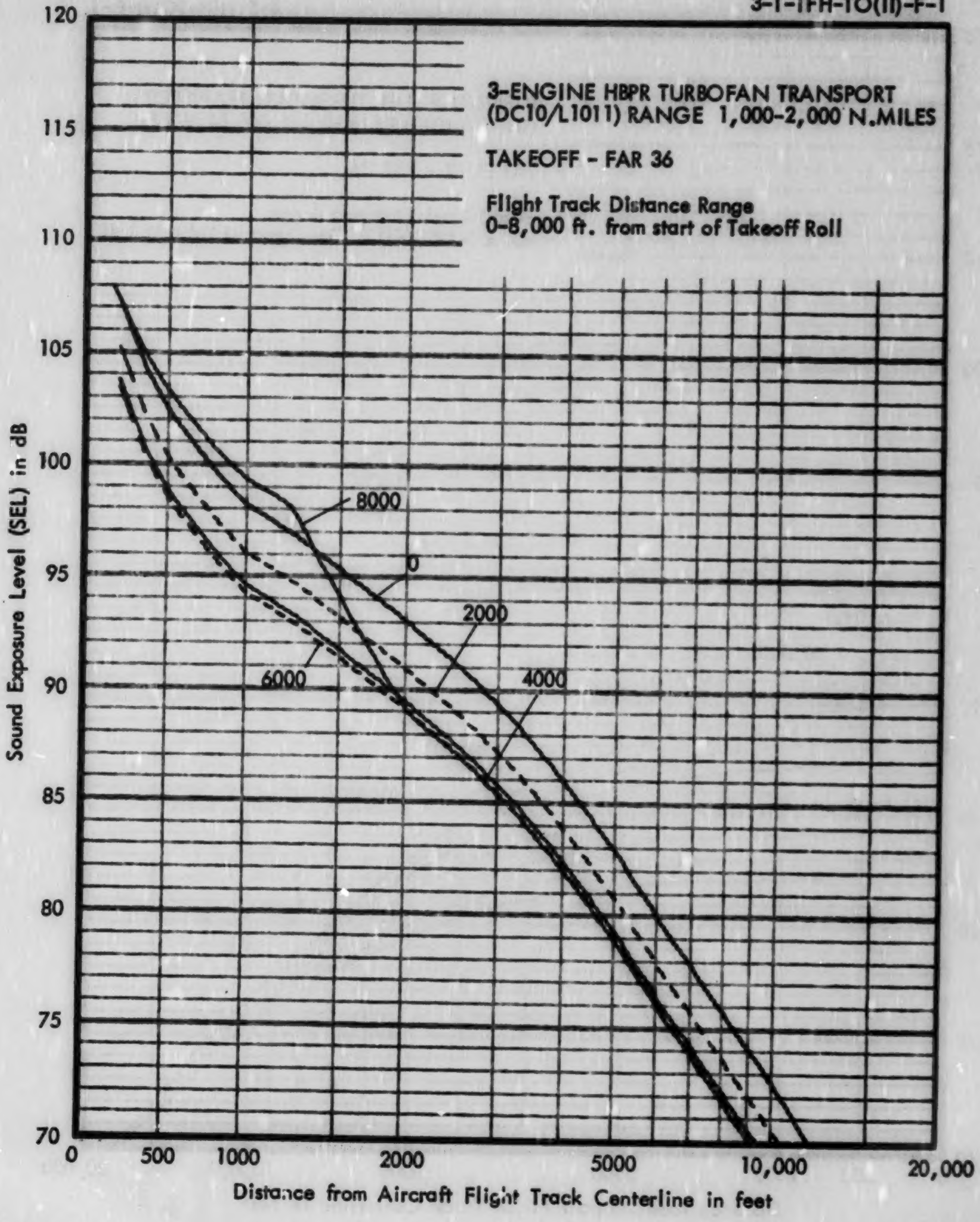
3-T-TFH-TO(I)-F-2


3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N.MILES
TAKEOFF - FAR 36
Power Cutback at 14,000 ft.
Flight Track Distance Range
8,000-40,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
8000
10,000
14,000
16,000
18,000
20,000
25,000
30,000
40,000
8000
10,000
14,000
16,000
18,000
20,000
25,000

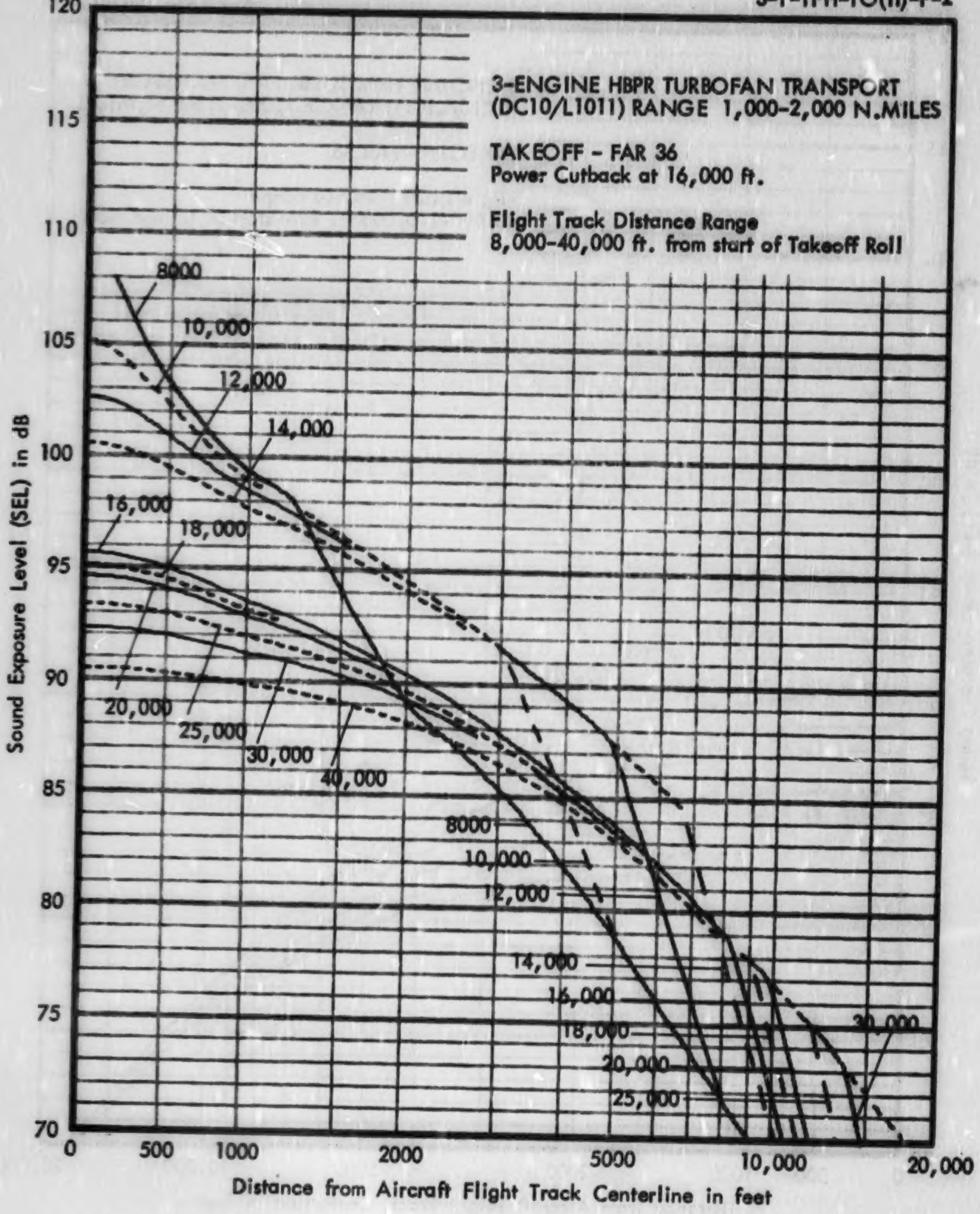
3-T-TFH-TO(I)-F-3


3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE 0-1,000 N.MILES
TAKEOFF - FAR 36
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll
40,000
50,000
60,000
80,000
100,000
120,000
140,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

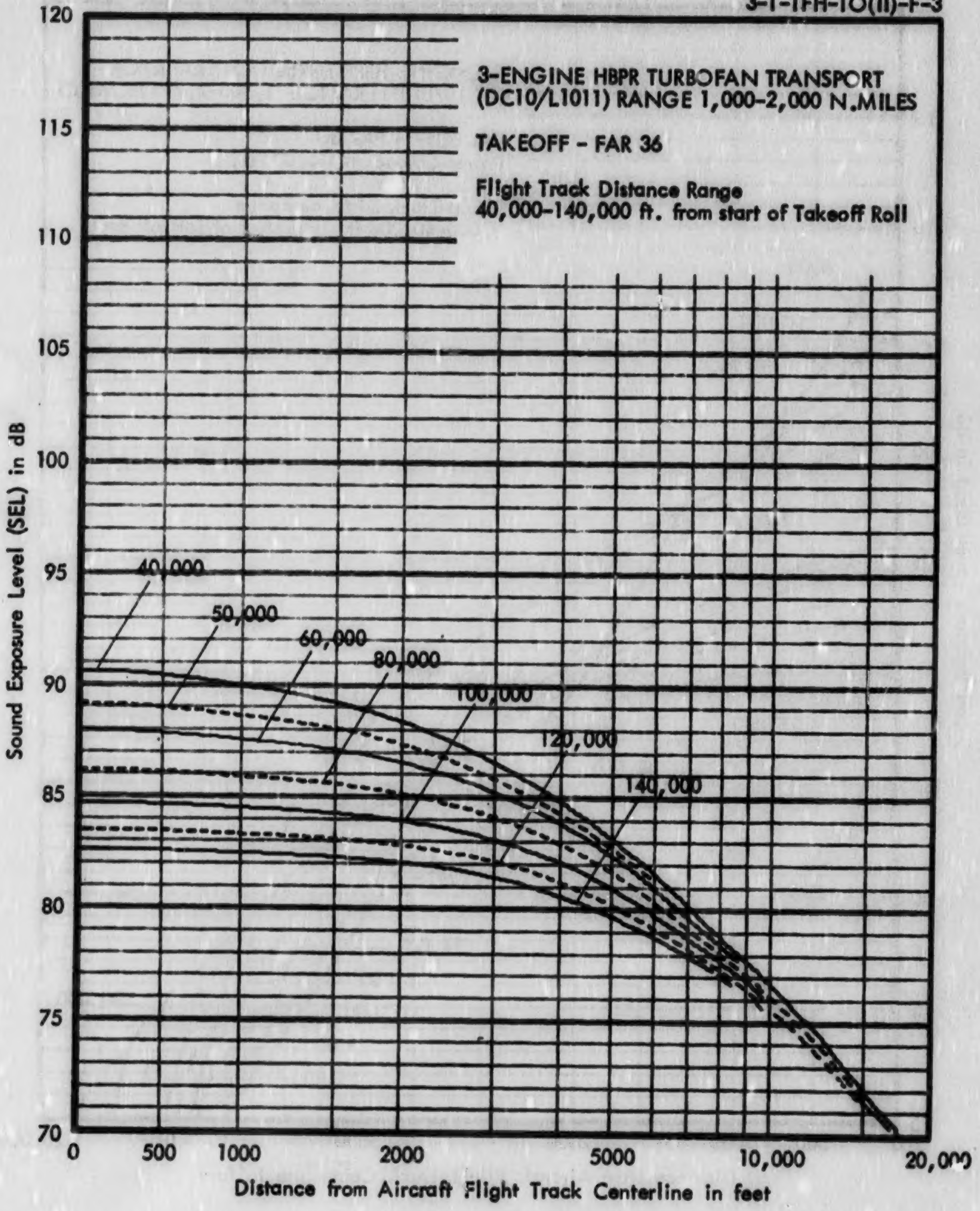
3-T-TFH-TO(II)-F-1



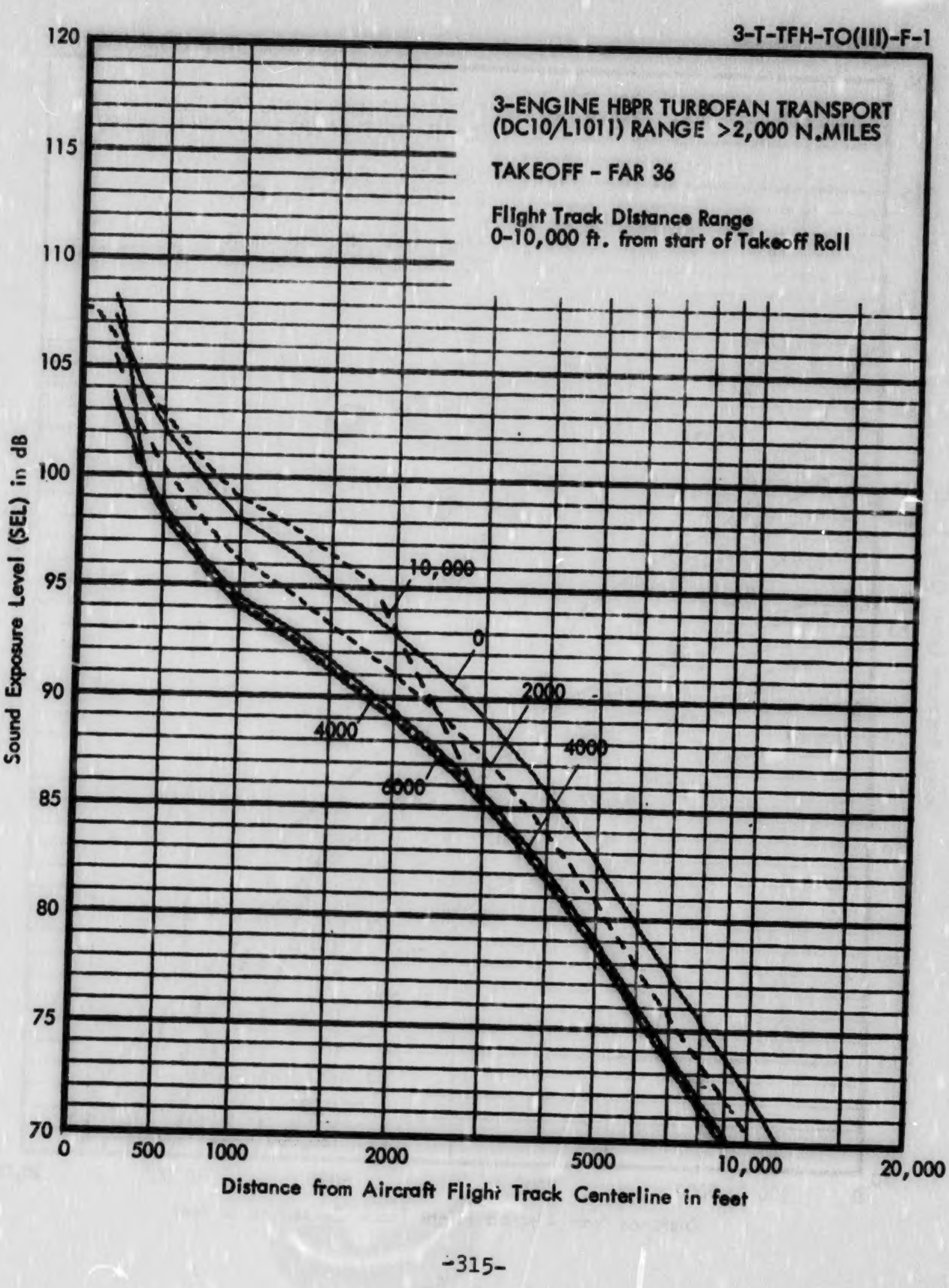
3-T-TFH-TO(II)-F-2

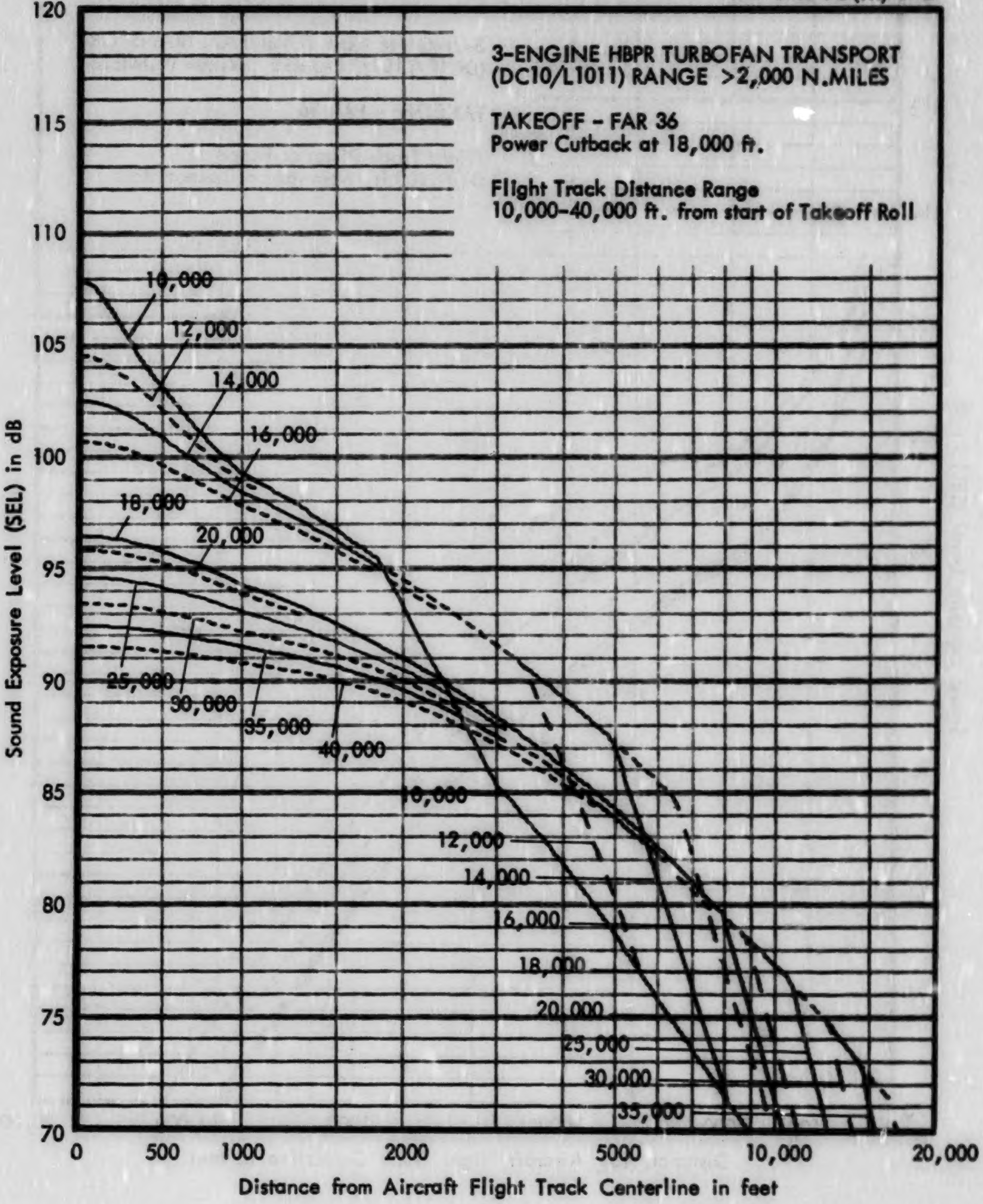


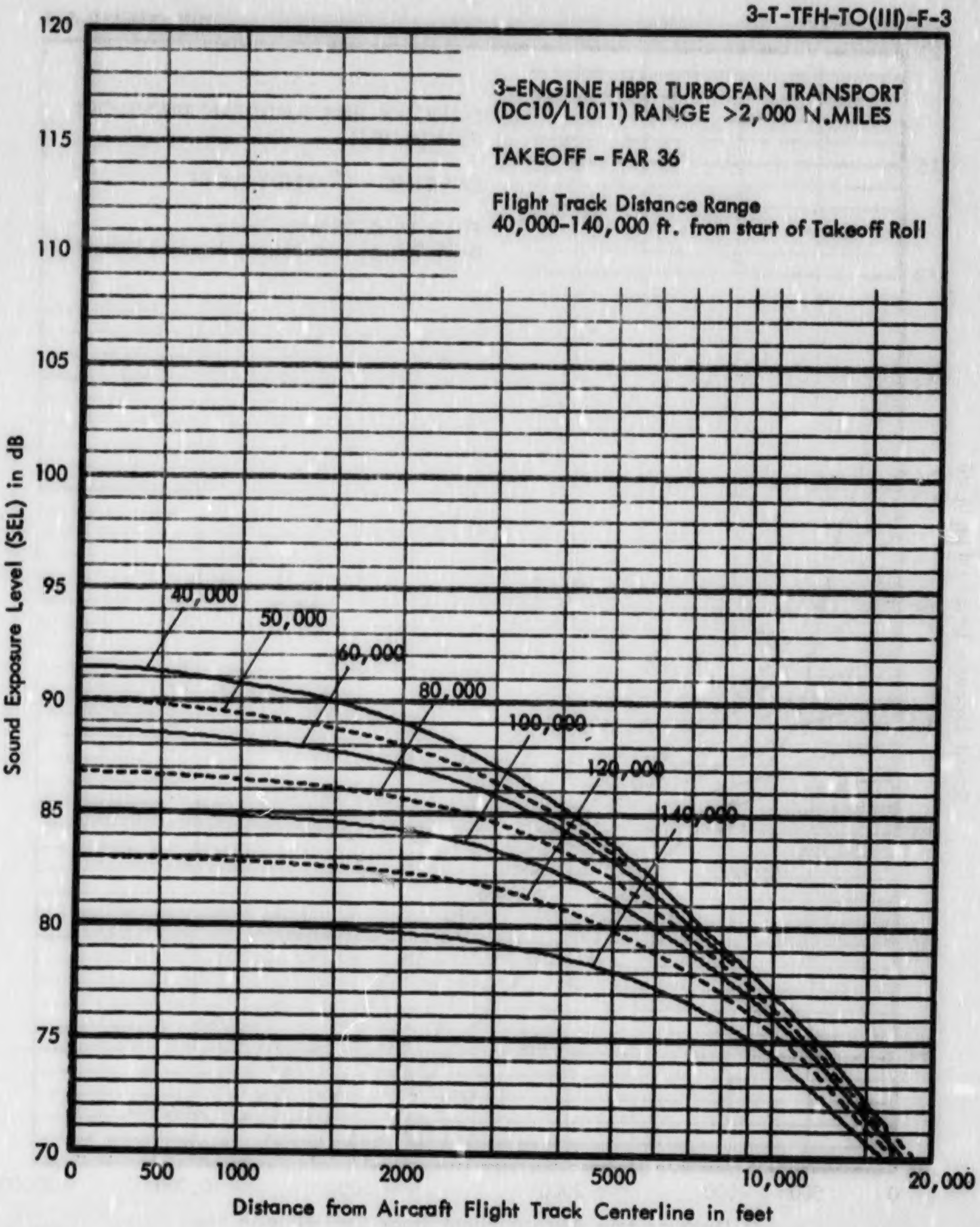
3-T-TFH-TO(II)-F-3



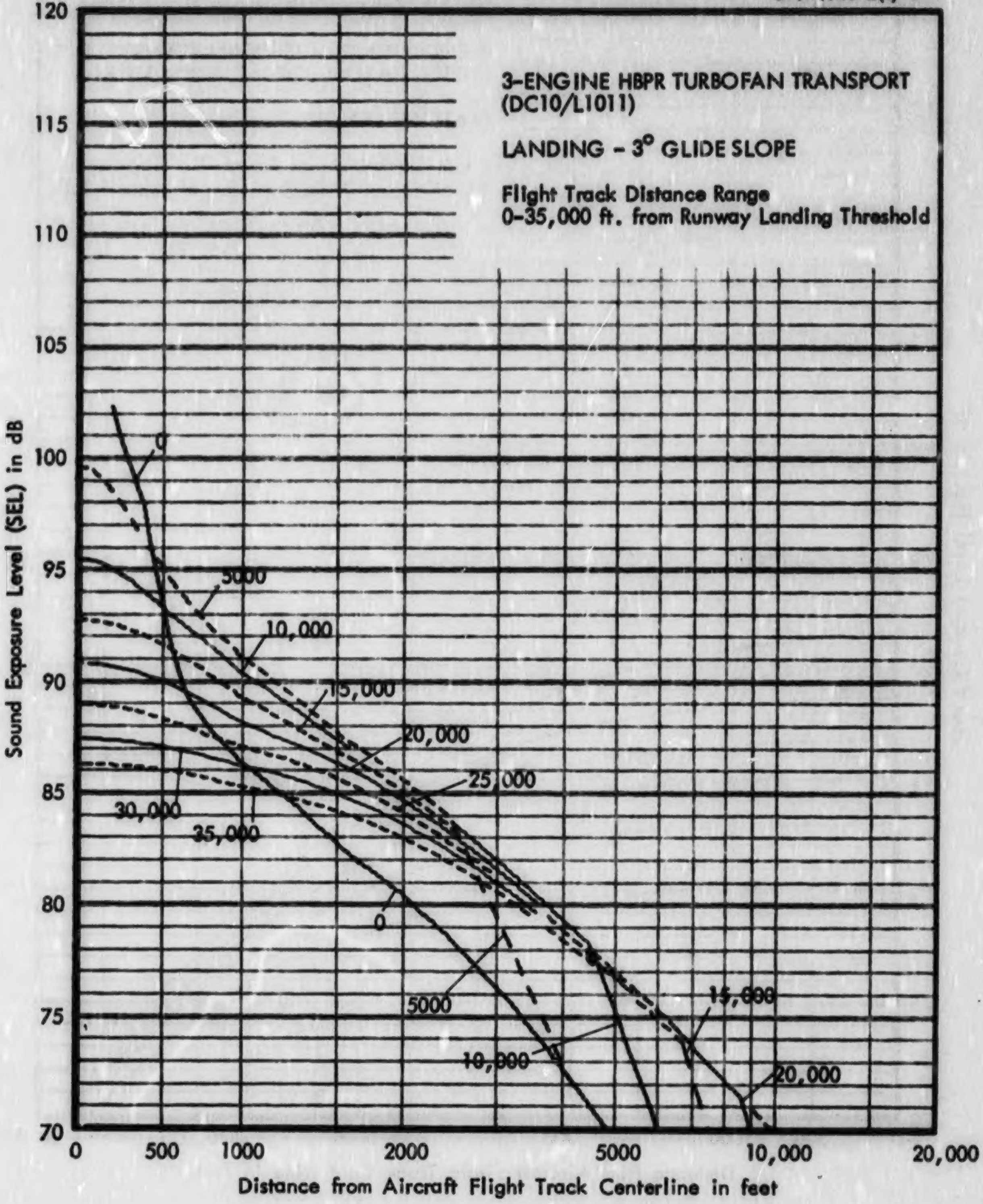
3-T-TFH-TO(III)-F-1



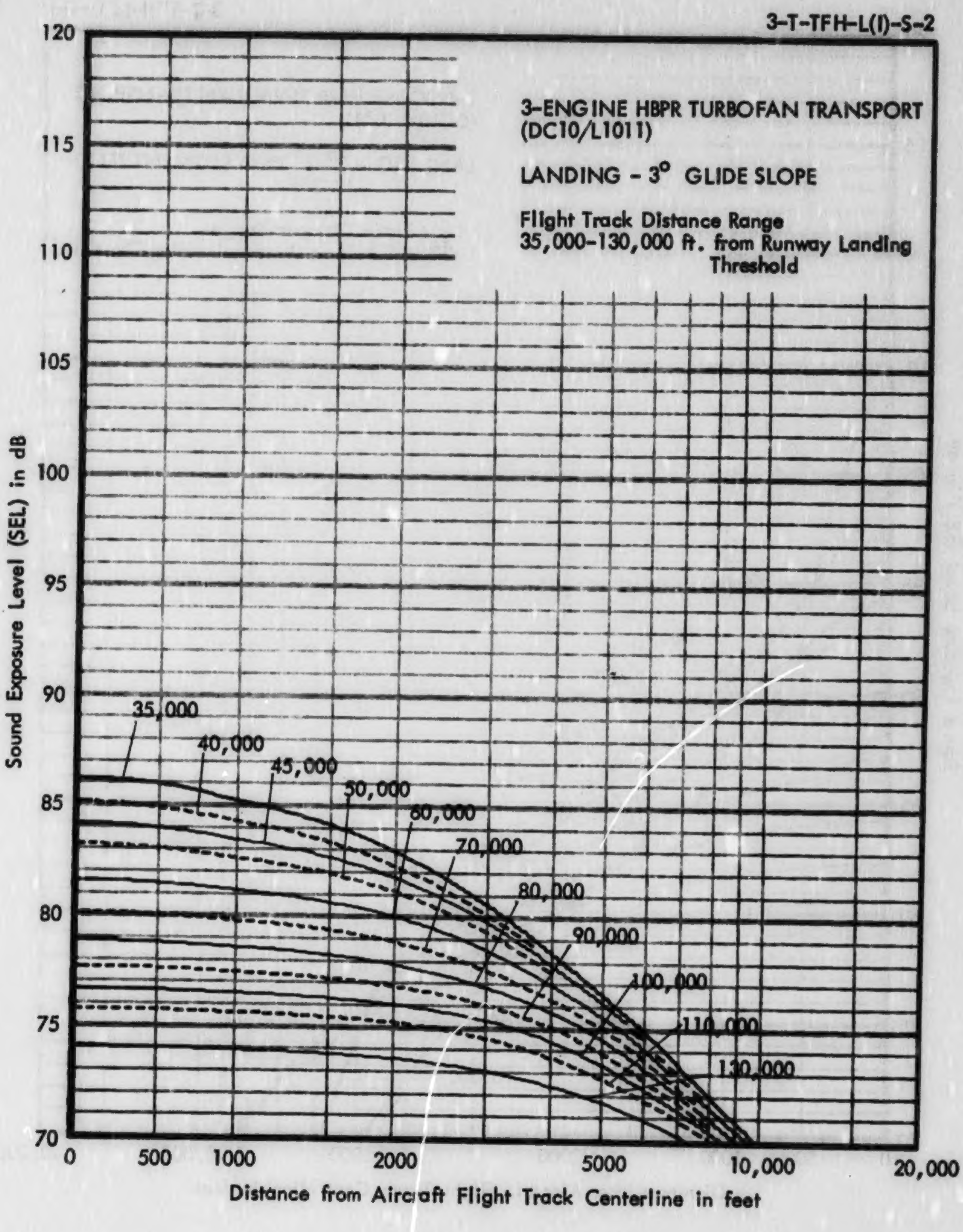

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE >2,000 N.MILES
TAKEOFF - FAR 36
Power Cutback at 18,000 ft.
Flight Track Distance Range
10,000-40,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000
40,000
10,000
12,000
14,000
16,000
18,000
20,000
25,000
30,000
35,000

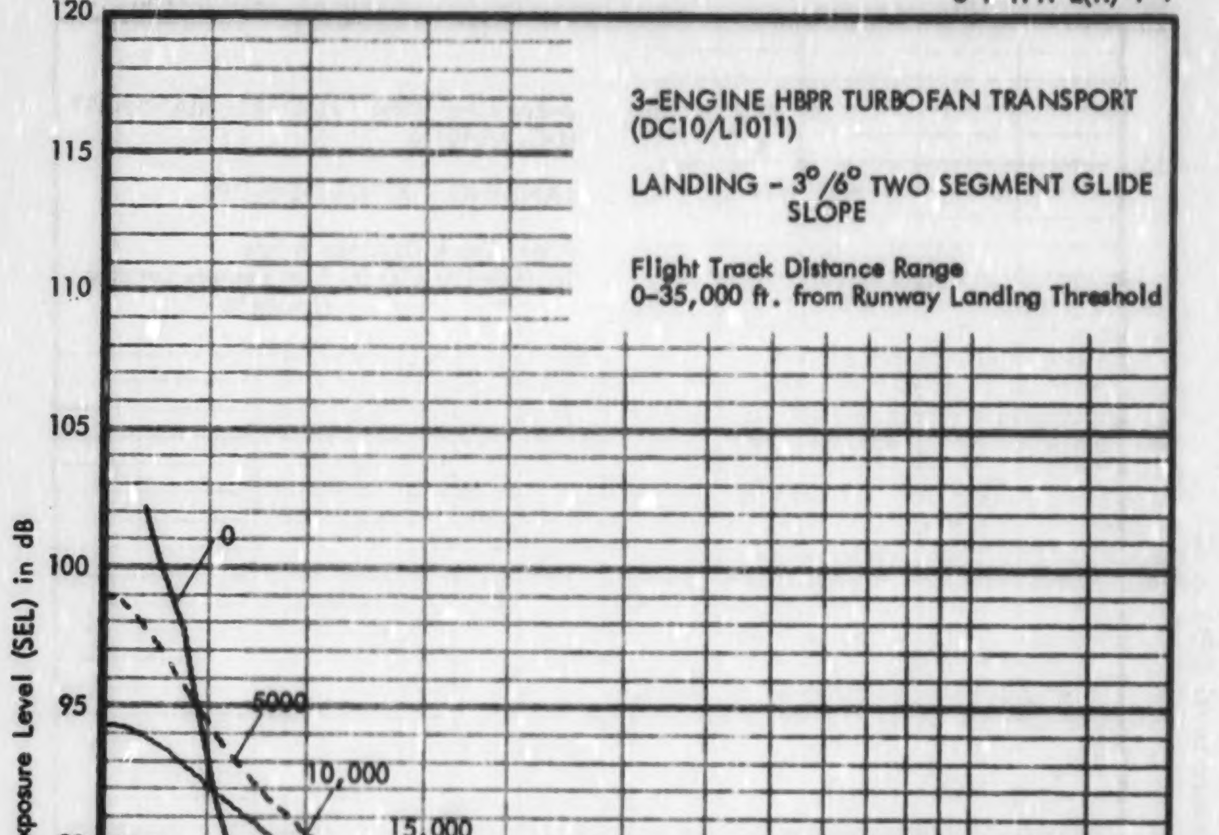

3-ENGINE HBPR TURBOFAN TRANSPORT
(DC10/L1011) RANGE >2,000 N.MILES
TAKEOFF - FAR 36
Flight Track Distance Range
40,000-140,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
40,000
50,000
60,000
80,000
100,000
120,000
140,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

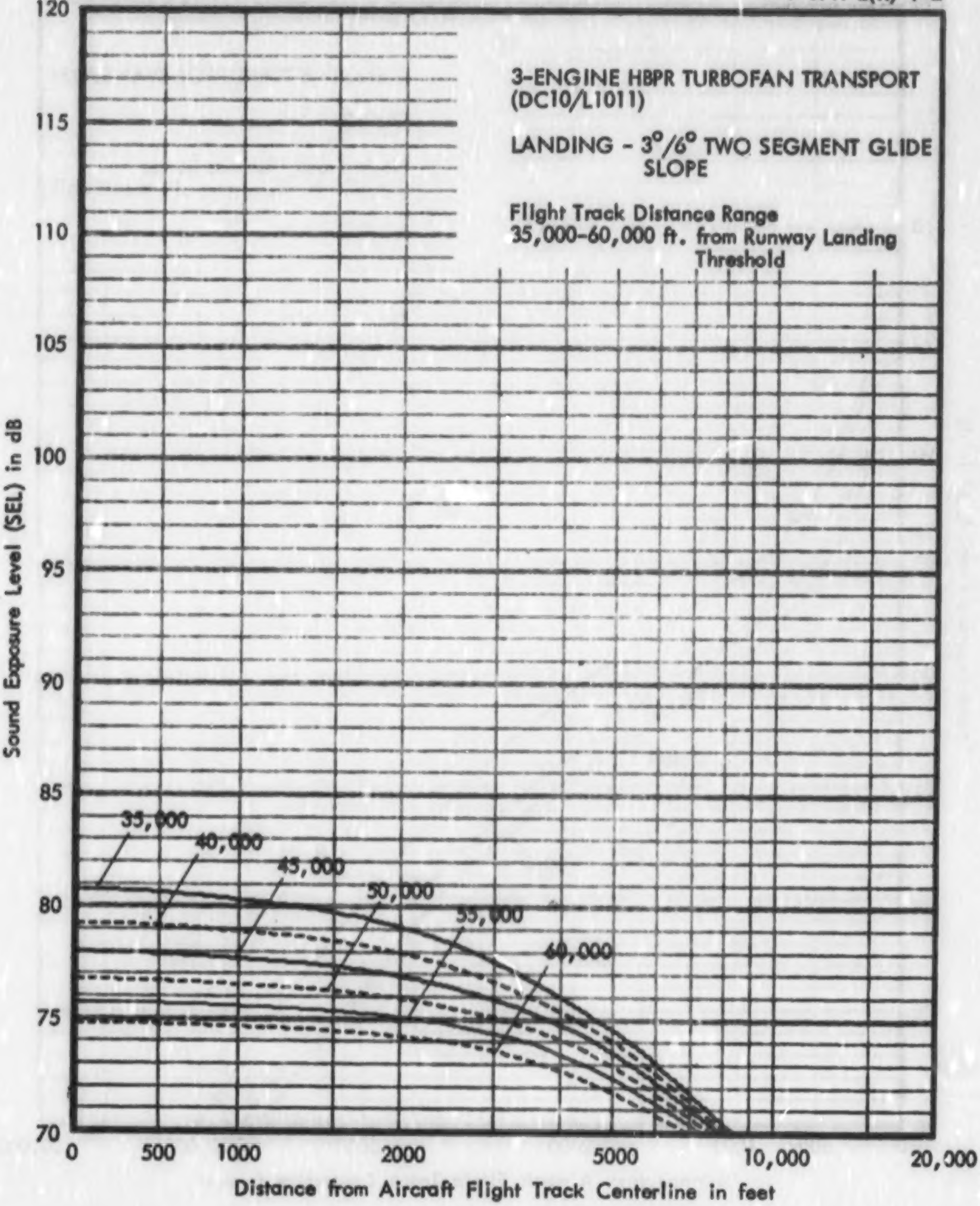
3-T-TFH-L(I)-S-1


3-ENGINE HBPR TURBOFAN TRANSPORT (DC10/L1011)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5000
10,000
15,000
20,000

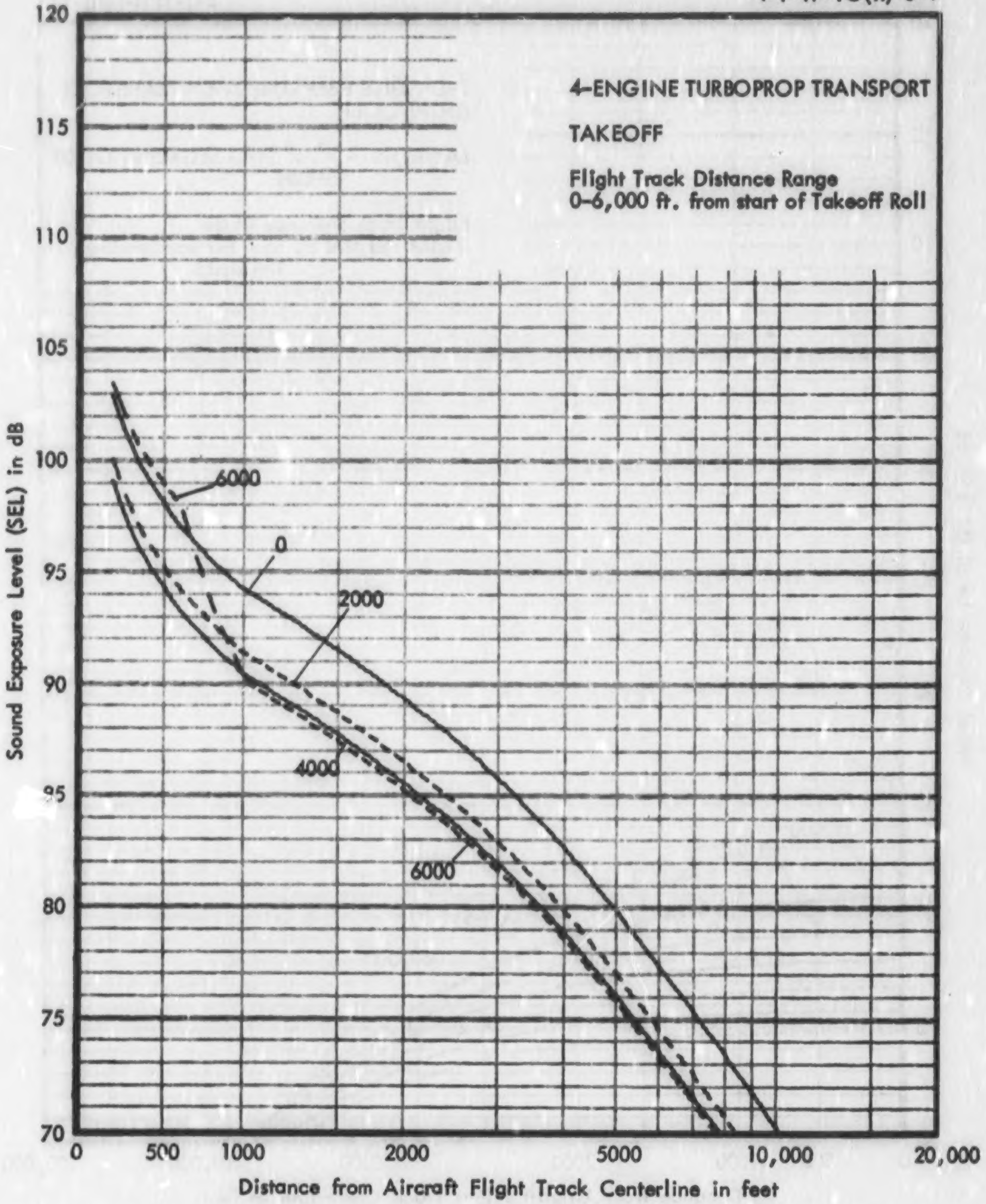
3-T-TFH-L(I)-S-2

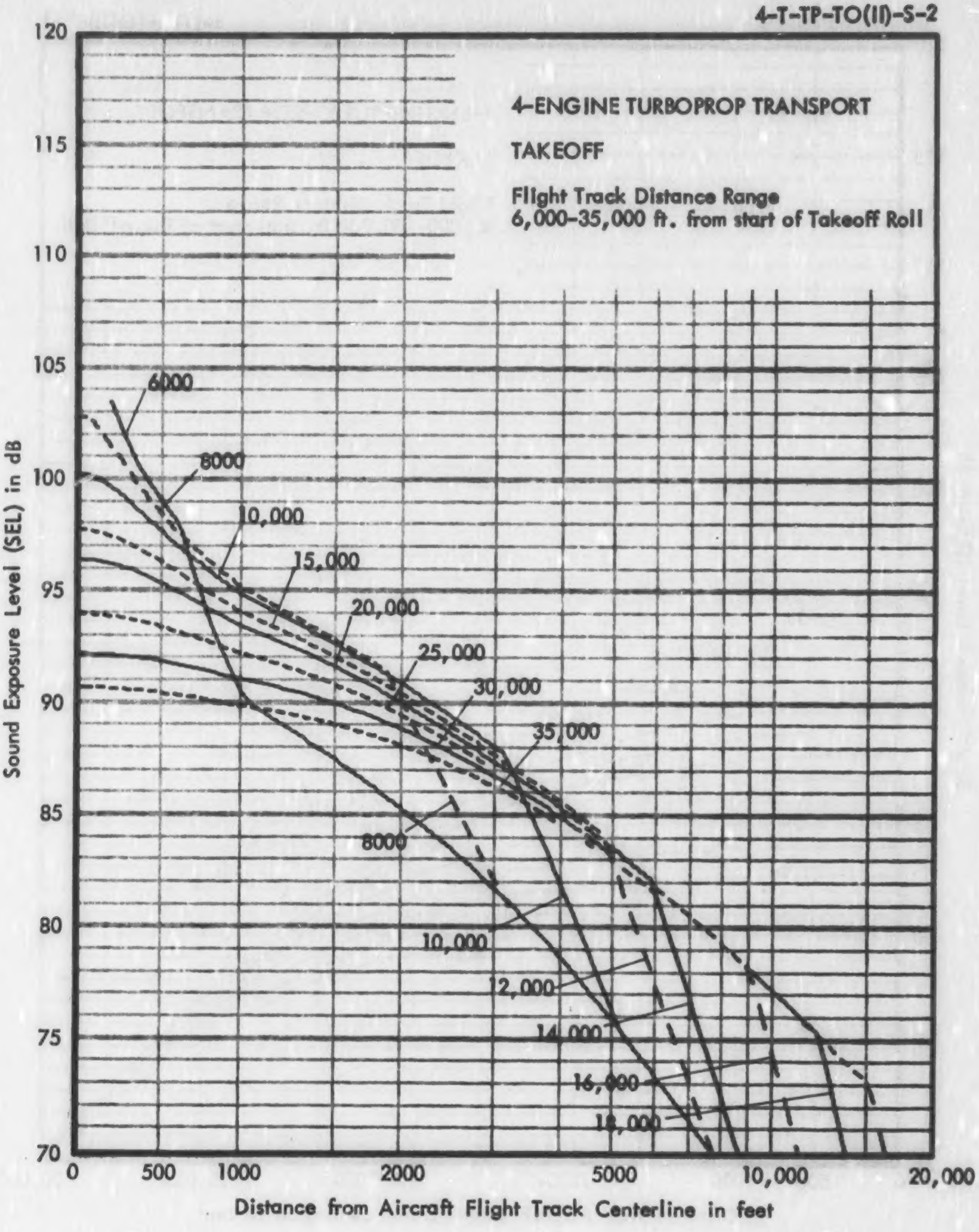

3-ENGINE HBPR TURBOFAN TRANSPORT (DC10/L1011)
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
35,000-130,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
45,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
130,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

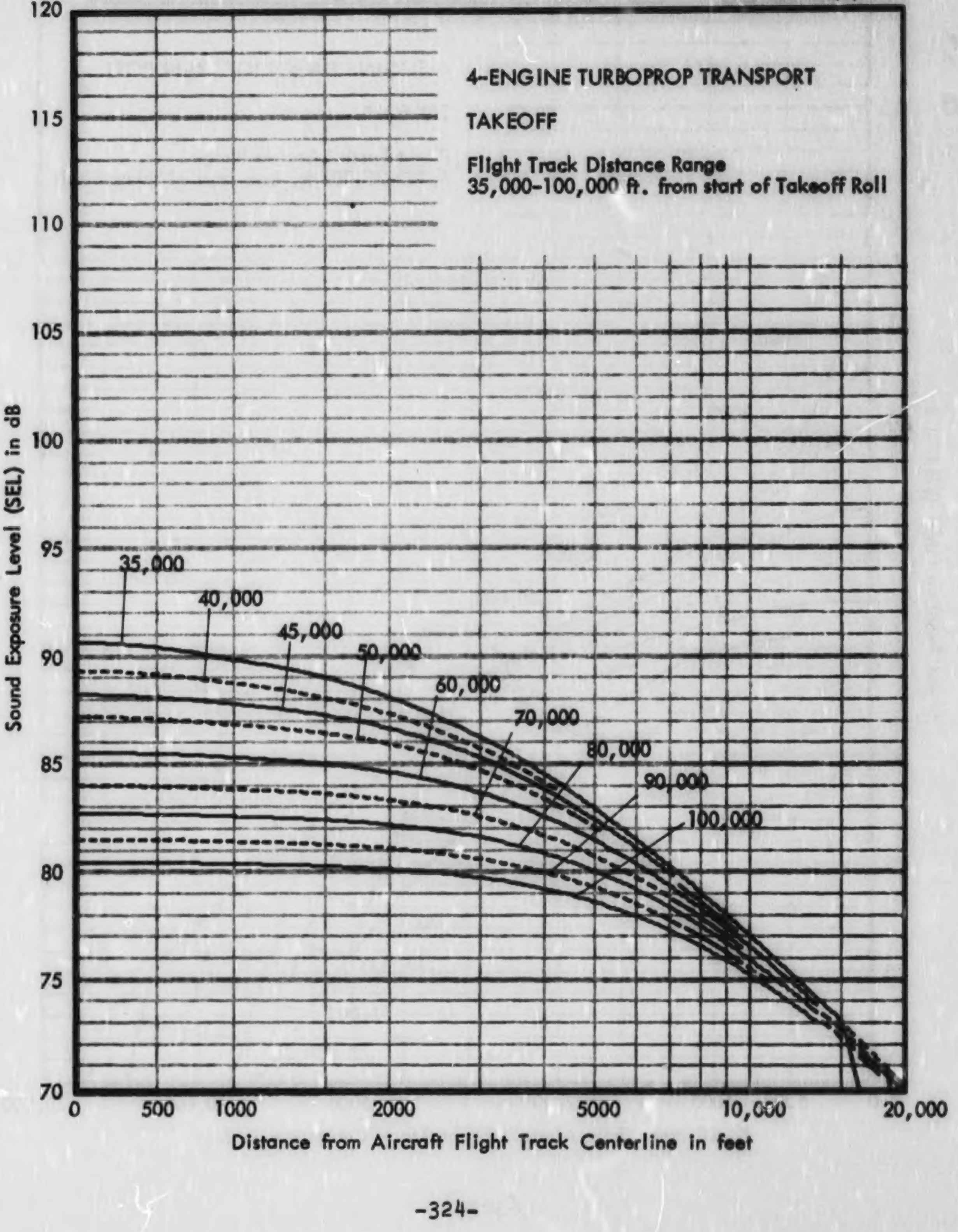

3-ENGINE HBPR TURBOFAN TRANSPORT (DC10/L1011)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range 0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5000
10,000

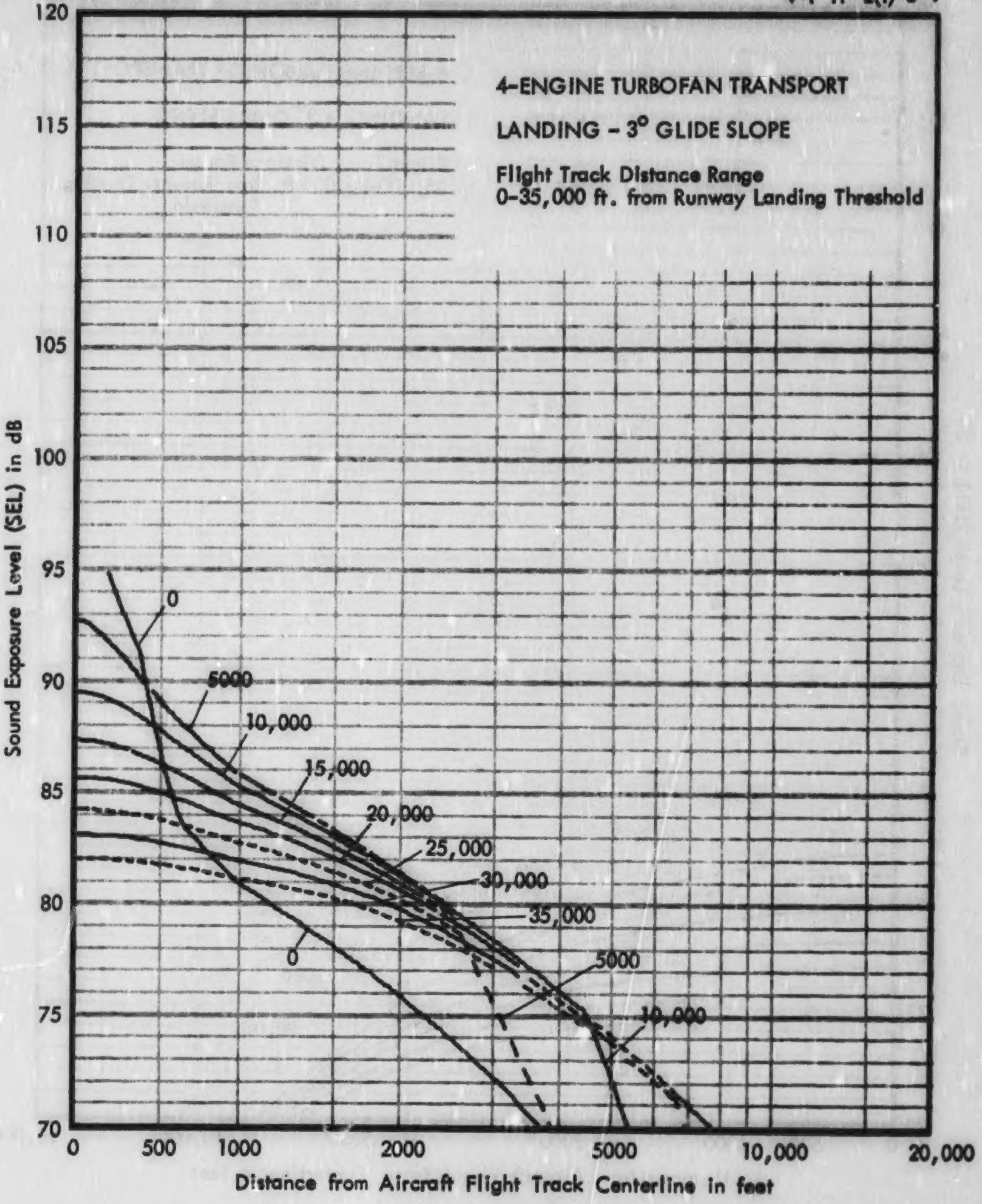

3-ENGINE HBPR TURBOFAN TRANSPORT (DC10/L1011)
LANDING - 3°/6° TWO SEGMENT GLIDE SLOPE
Flight Track Distance Range 35,000-60,000 ft. from Runway Landing Threshold
35,000
40,000
45,000
50,000
55,000
60,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

4-T-TP-TO(II)-S-1

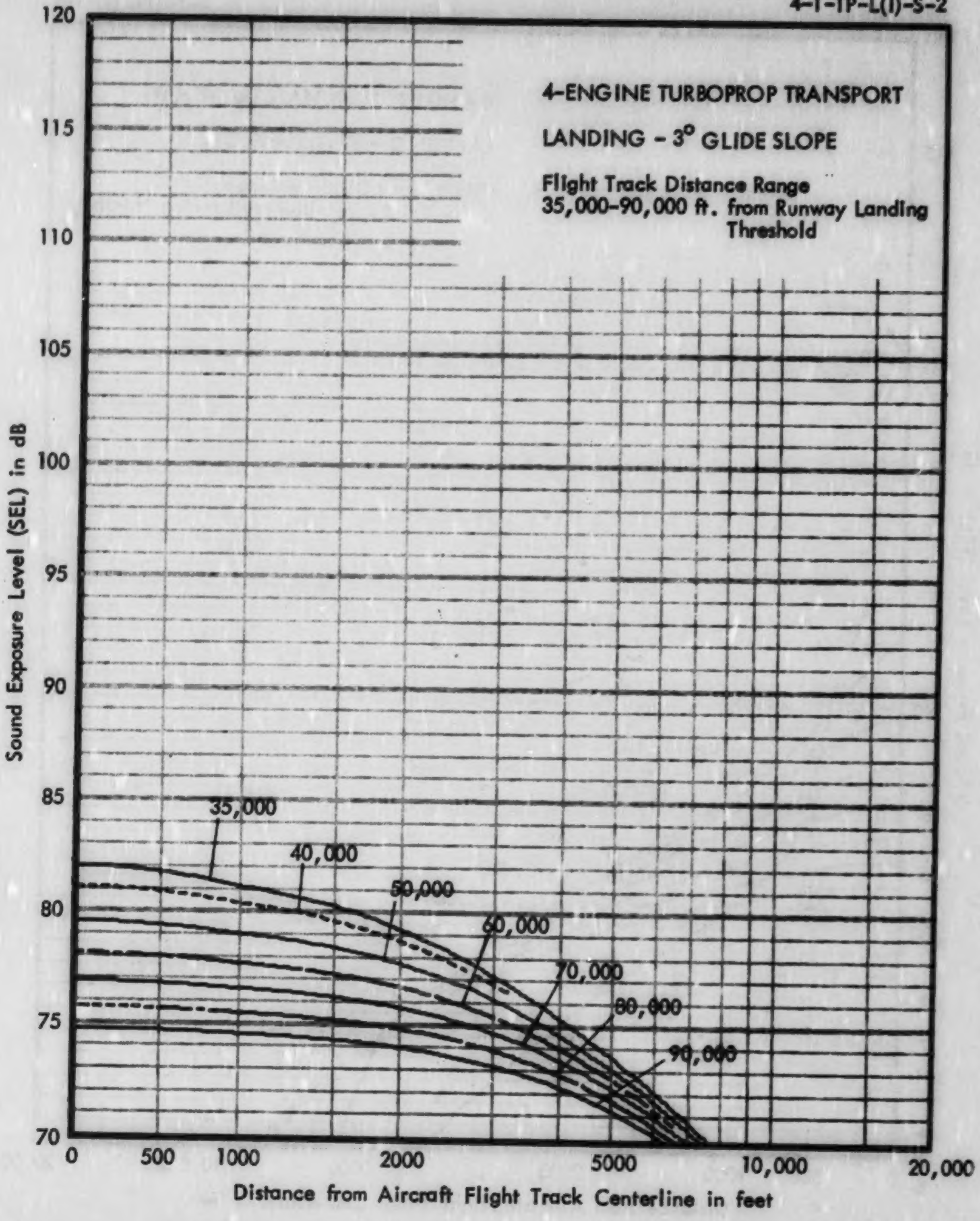

4-ENGINE TURBOPROP TRANSPORT
TAKEOFF
Flight Track Distance Range
0-6,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
6000
0
2000
4000
6000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE TURBOPROP TRANSPORT
TAKEOFF
Flight Track Distance Range
6,000-35,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
6000
8000
10,000
15,000
20,000
25,000
30,000
35,000
8000
10,000
12,000
14,000
16,000
18,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

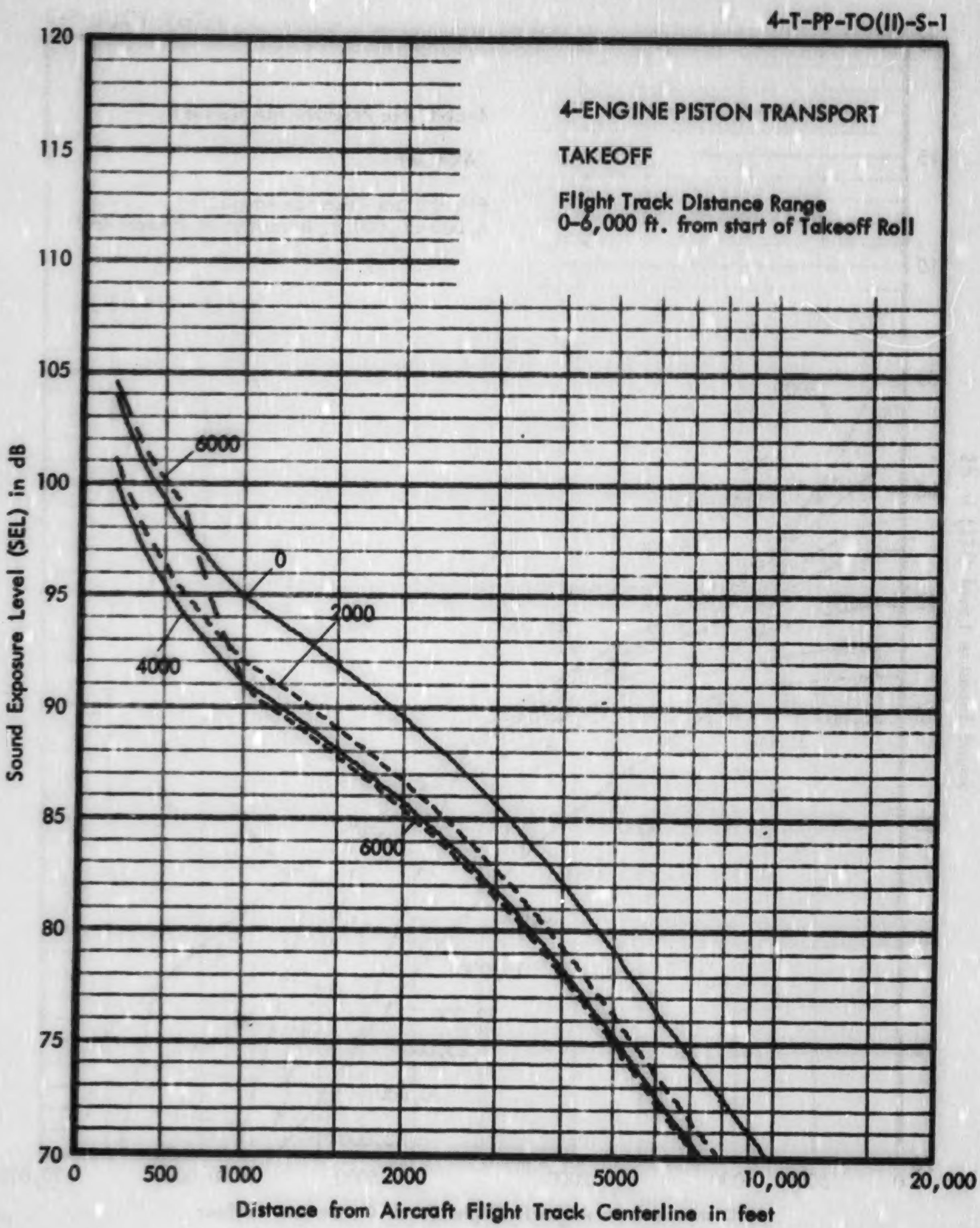

4-ENGINE TURBOPROP TRANSPORT
TAKEOFF
Flight Track Distance Range
35,000-100,000 ft. from start of Takeoff Roll
35,000
40,000
45,000
50,000
60,000
70,000
80,000
90,000
100,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE TURBOFAN TRANSPORT
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5000
10,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

4-T-TP-L(I)-S-2

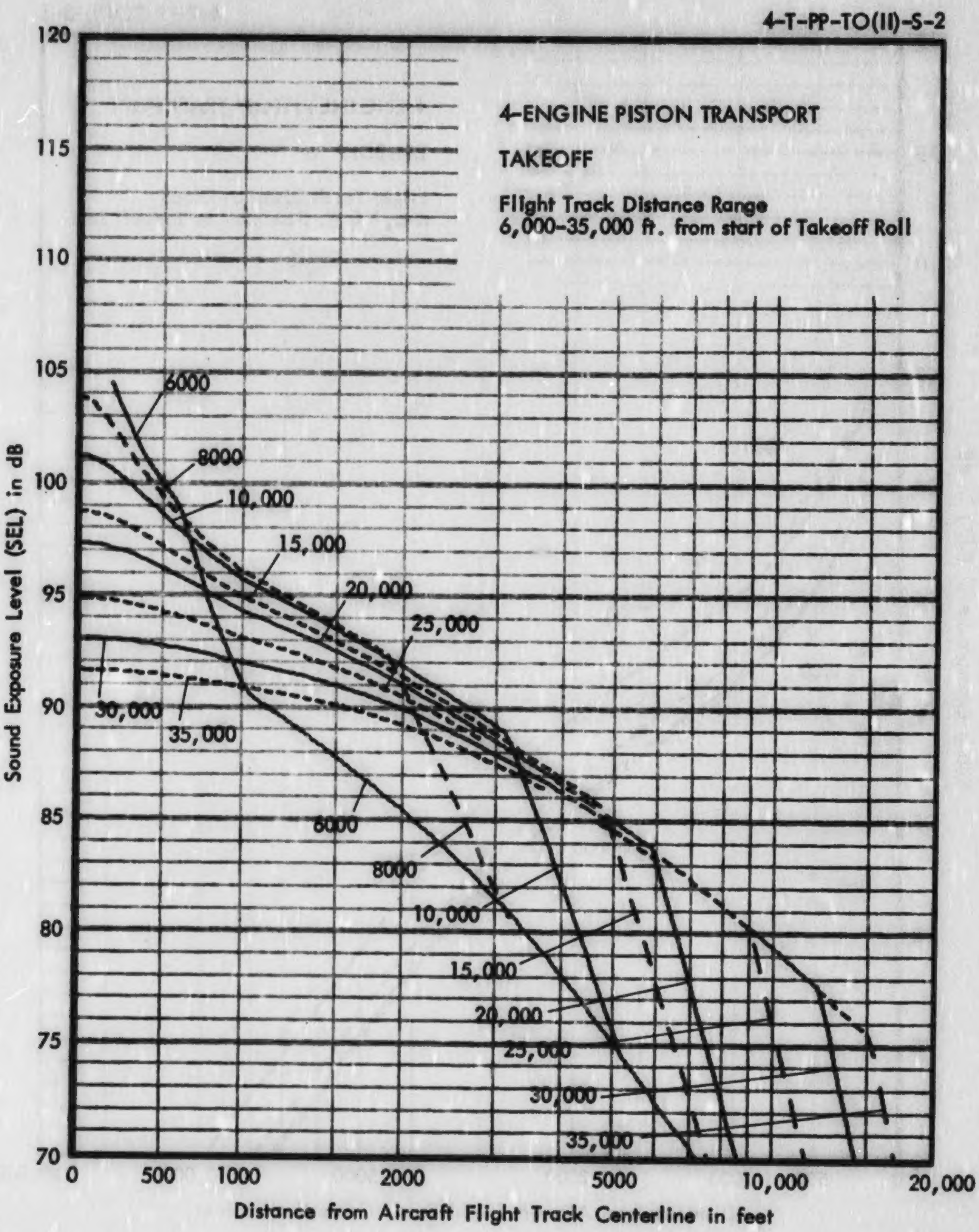

4-ENGINE TURBOPROP TRANSPORT
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range 35,000-90,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
35,000
40,000
50,000
60,000
70,000
80,000
90,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

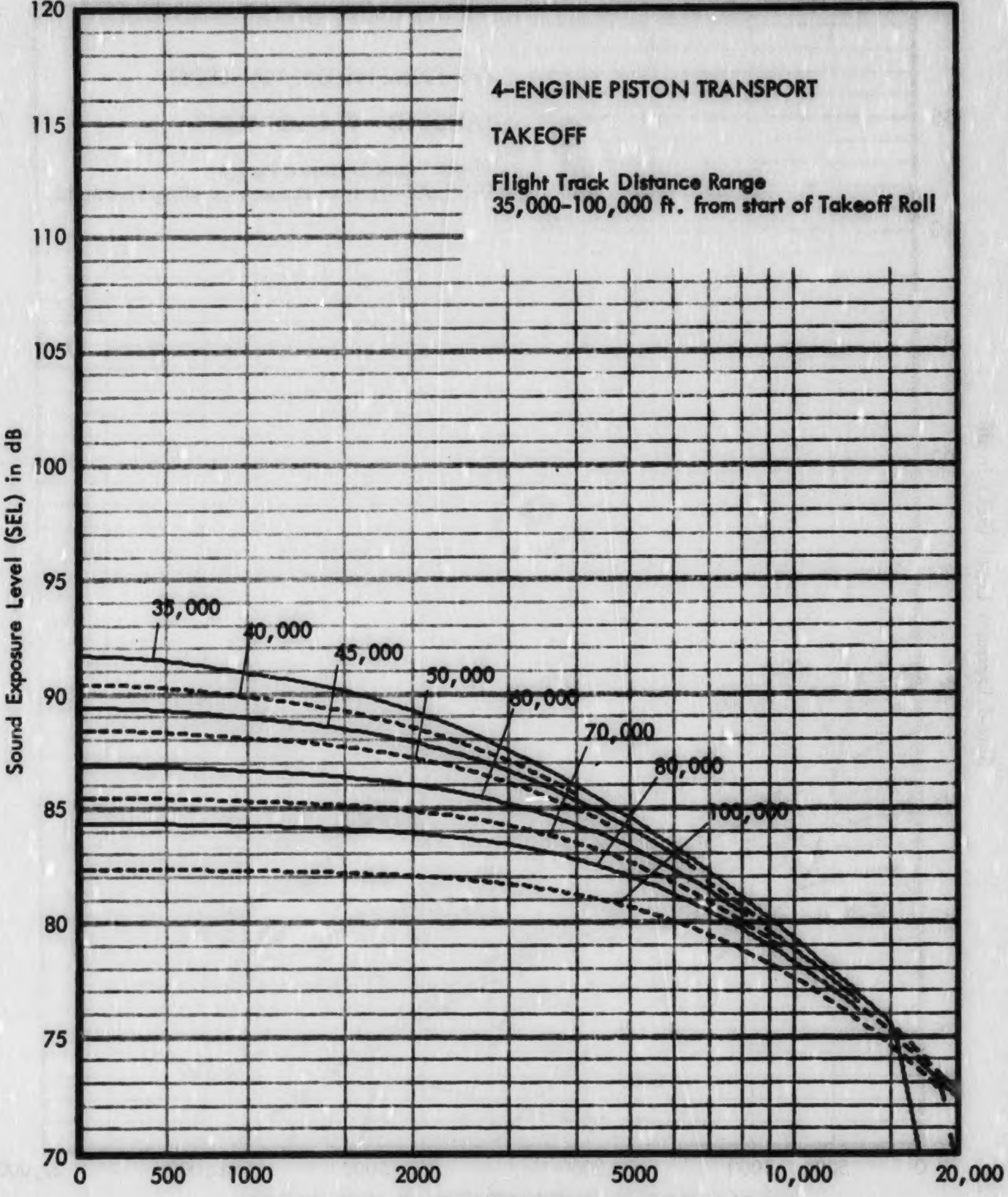
4-T-PP-TO(II)-S-1

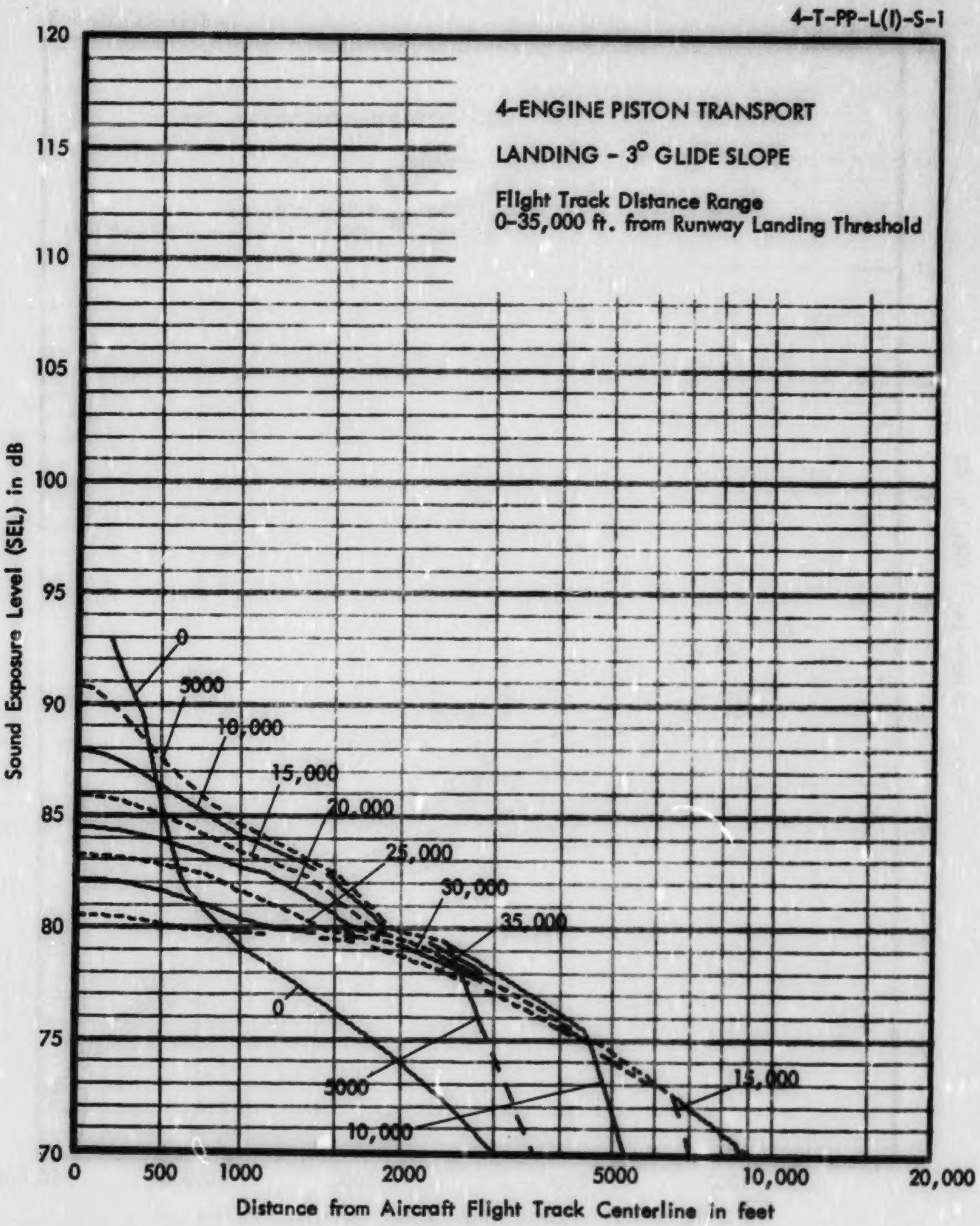


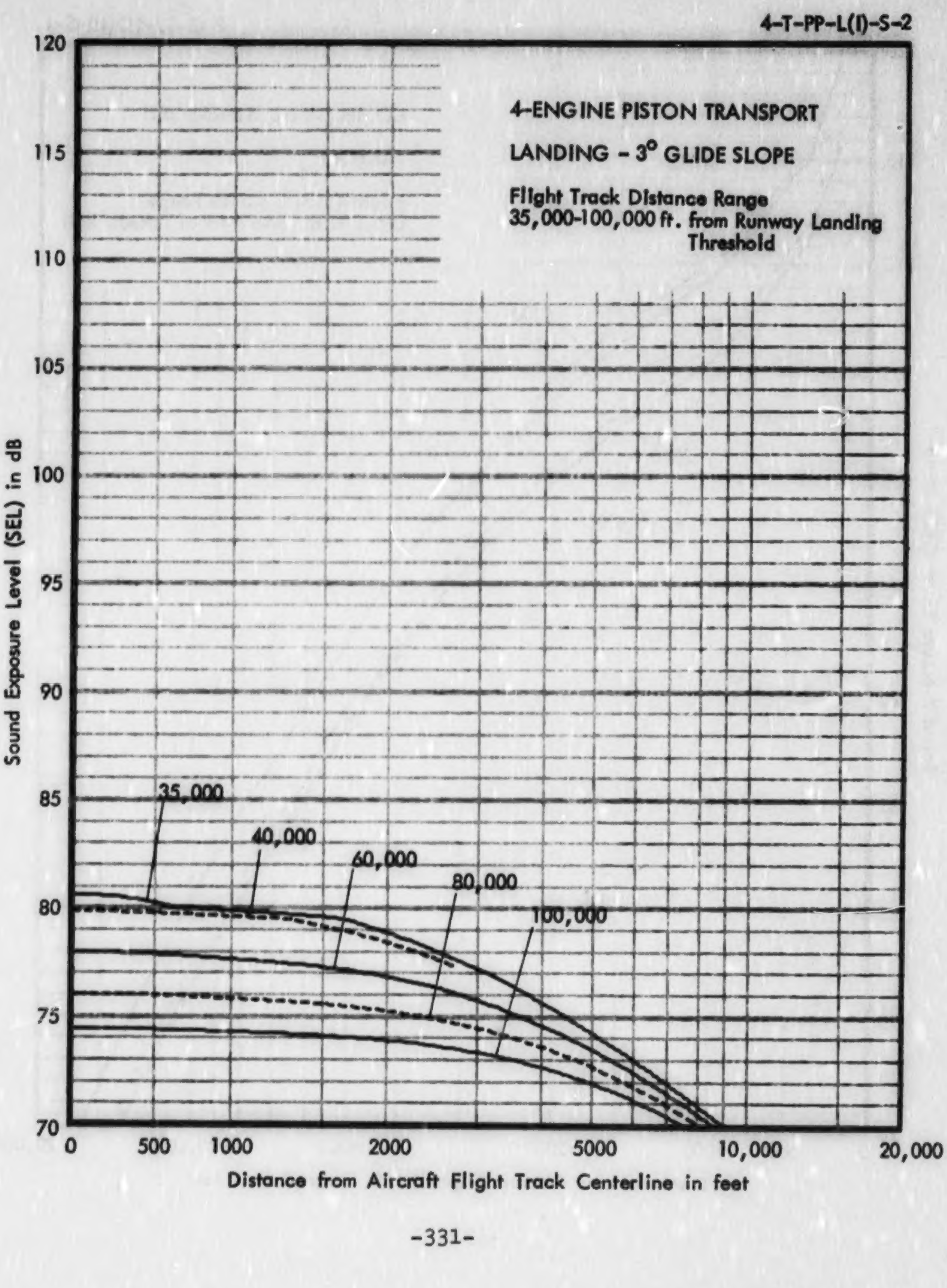
4-ENGINE PISTON TRANSPORT
TAKEOFF
Flight Track Distance Range
0-6,000 ft. from start of Takeoff Roll
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
6000
0
2000
4000
6000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

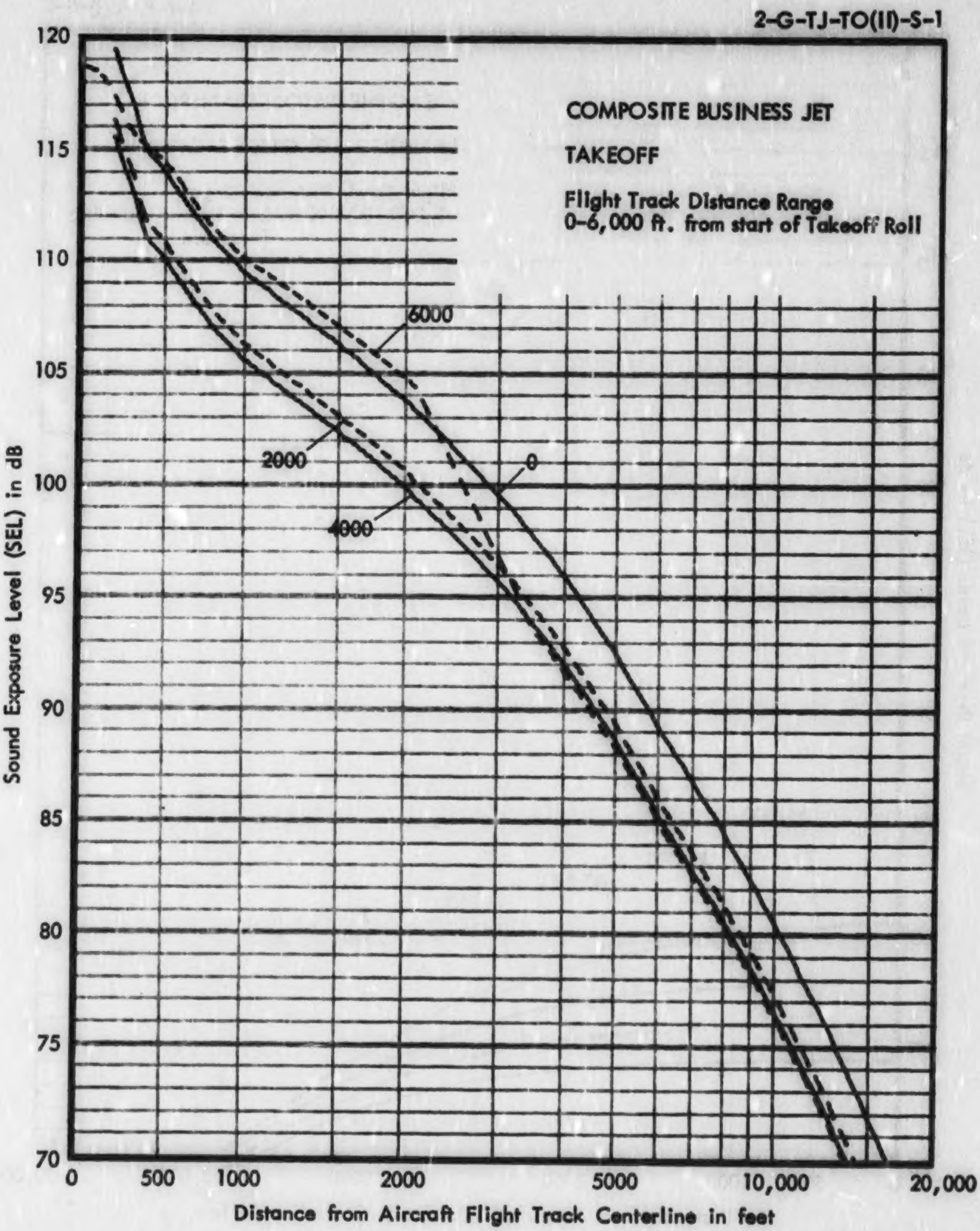
4-T-PP-TO(II)-S-2

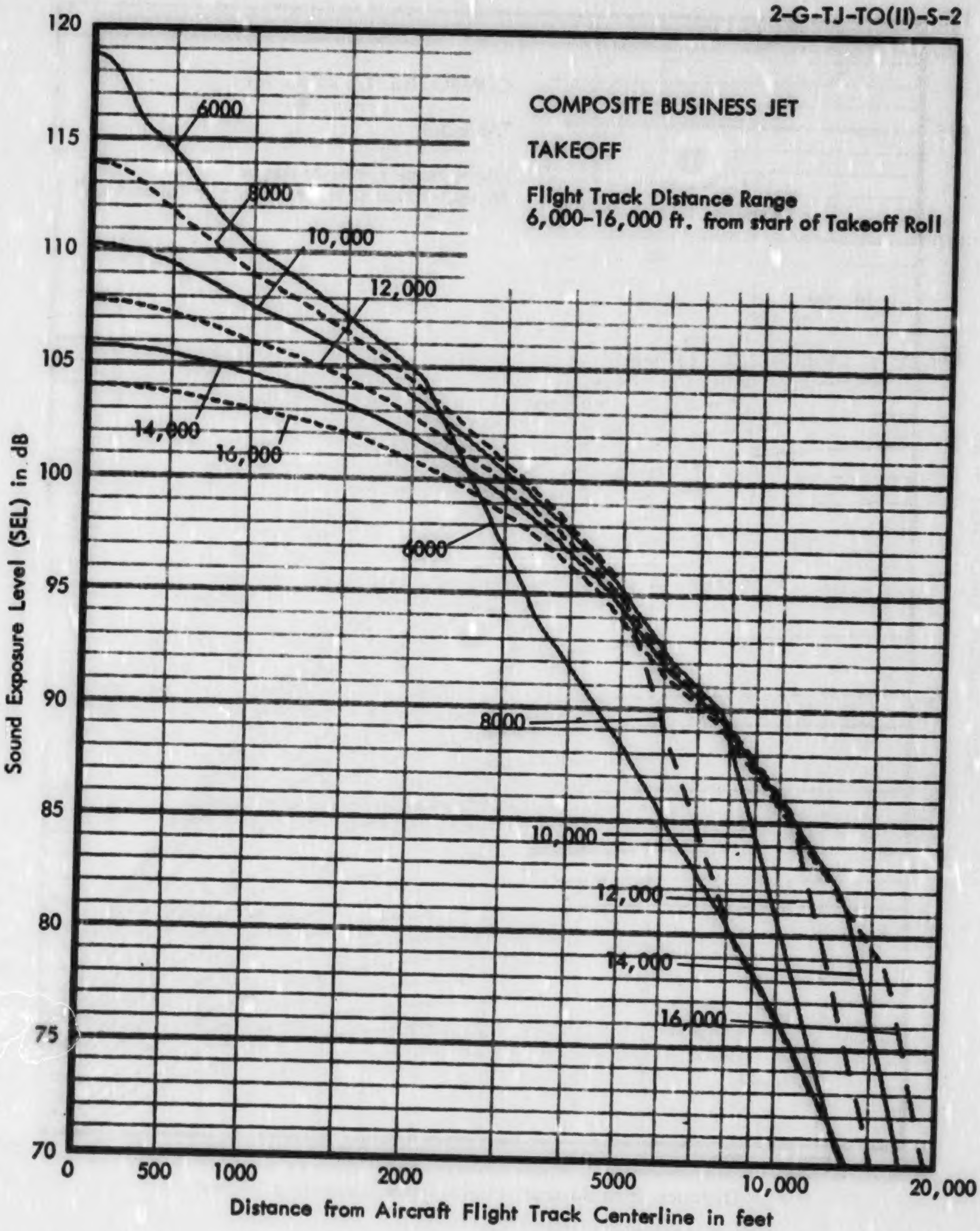

4-ENGINE PISTON TRANSPORT
TAKEOFF
Flight Track Distance Range
6,000-35,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
6000
8000
10,000
15,000
20,000
25,000
30,000
35,000
6000
8000
10,000
15,000
20,000
25,000
30,000
35,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

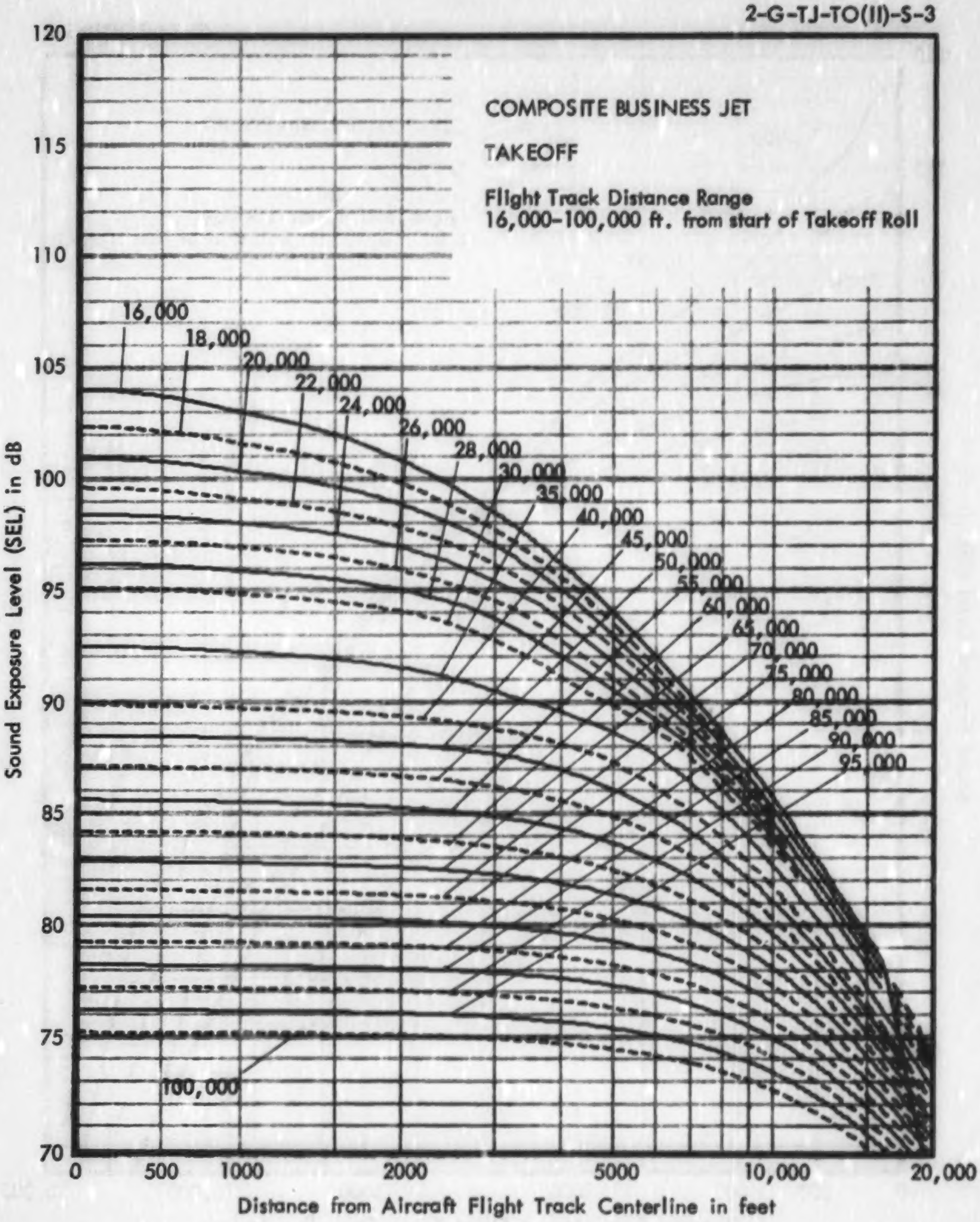

4-ENGINE PISTON TRANSPORT
TAKEOFF
Flight Track Distance Range
35,000-100,000 ft. from start of Takeoff Roll
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
35,000
40,000
45,000
50,000
60,000
70,000
80,000
100,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


4-ENGINE PISTON TRANSPORT
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5000
10,000
15,000

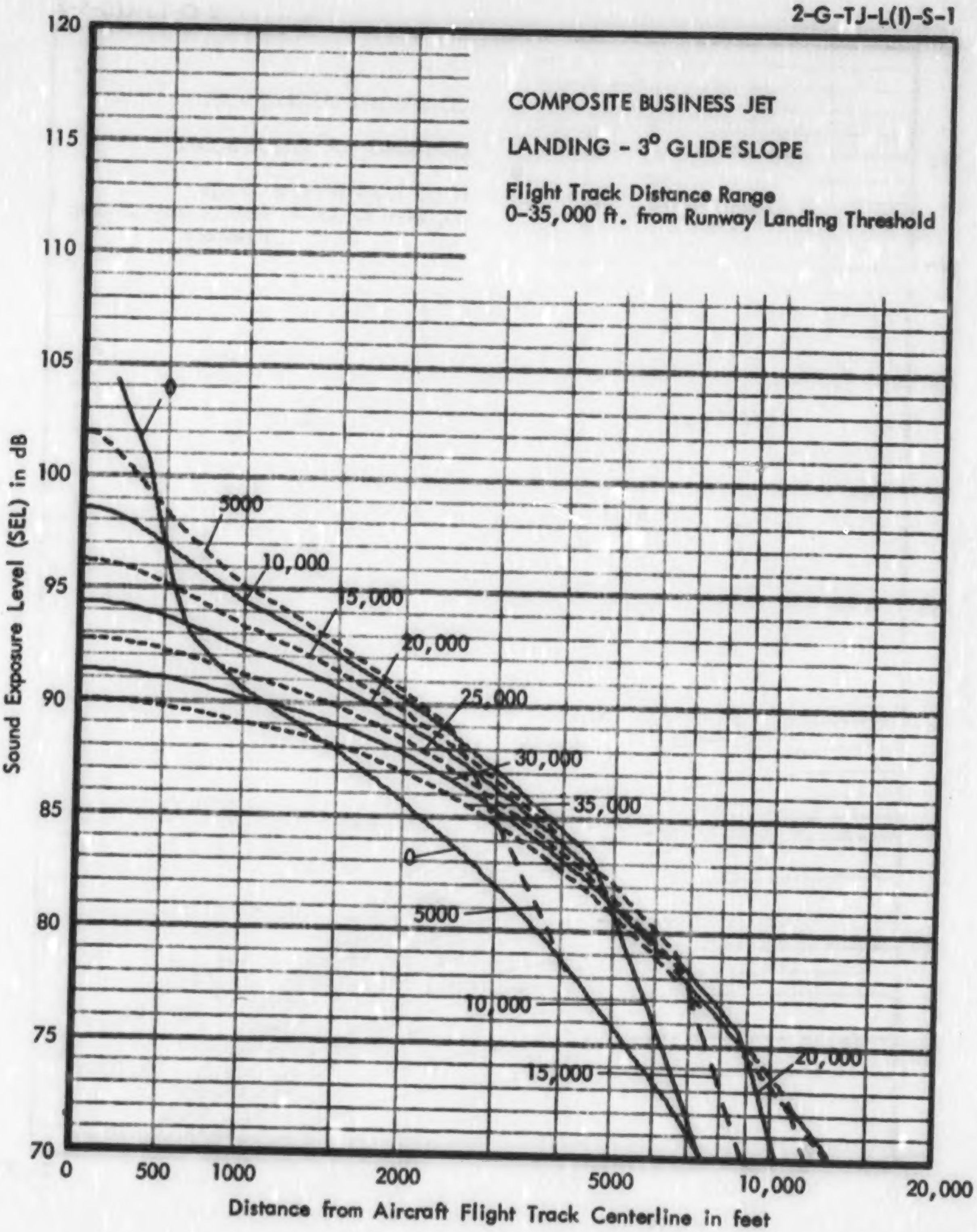

4-ENGINE PISTON TRANSPORT
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range 35,000-100,000 ft. from Runway Landing Threshold
35,000
40,000
60,000
80,000
100,000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


COMPOSITE BUSINESS JET
TAKEOFF
Flight Track Distance Range
0-6,000 ft. from start of Takeoff Roll
6000
2000
0
4000
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

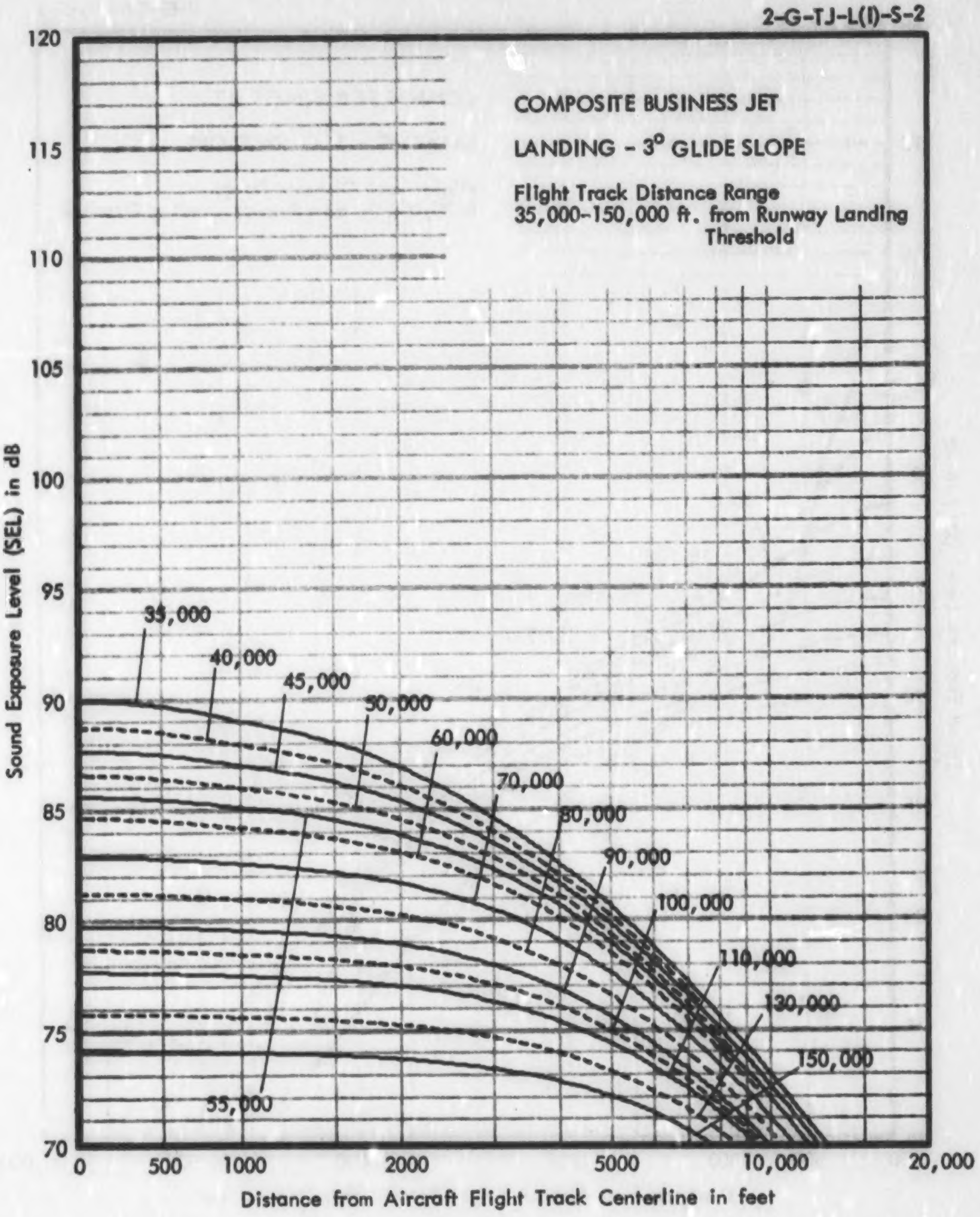

COMPOSITE BUSINESS JET
TAKEOFF
Flight Track Distance Range
6,000-16,000 ft. from start of Takeoff Roll
6000
8000
10,000
12,000
14,000
16,000
6000
8000
10,000
12,000
14,000
16,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


COMPOSITE BUSINESS JET
TAKEOFF
Flight Track Distance Range
16,000–100,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
16,000
18,000
20,000
22,000
24,000
26,000
28,000
30,000
35,000
40,000
45,000
50,000
55,000
60,000
65,000
70,000
75,000
80,000
85,000
90,000
95,000
100,000

2-G-TJ-L(I)-S-1


COMPOSITE BUSINESS JET
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-35,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
0
5000
10,000
15,000
20,000

2-G-TJ-L(I)-S-2

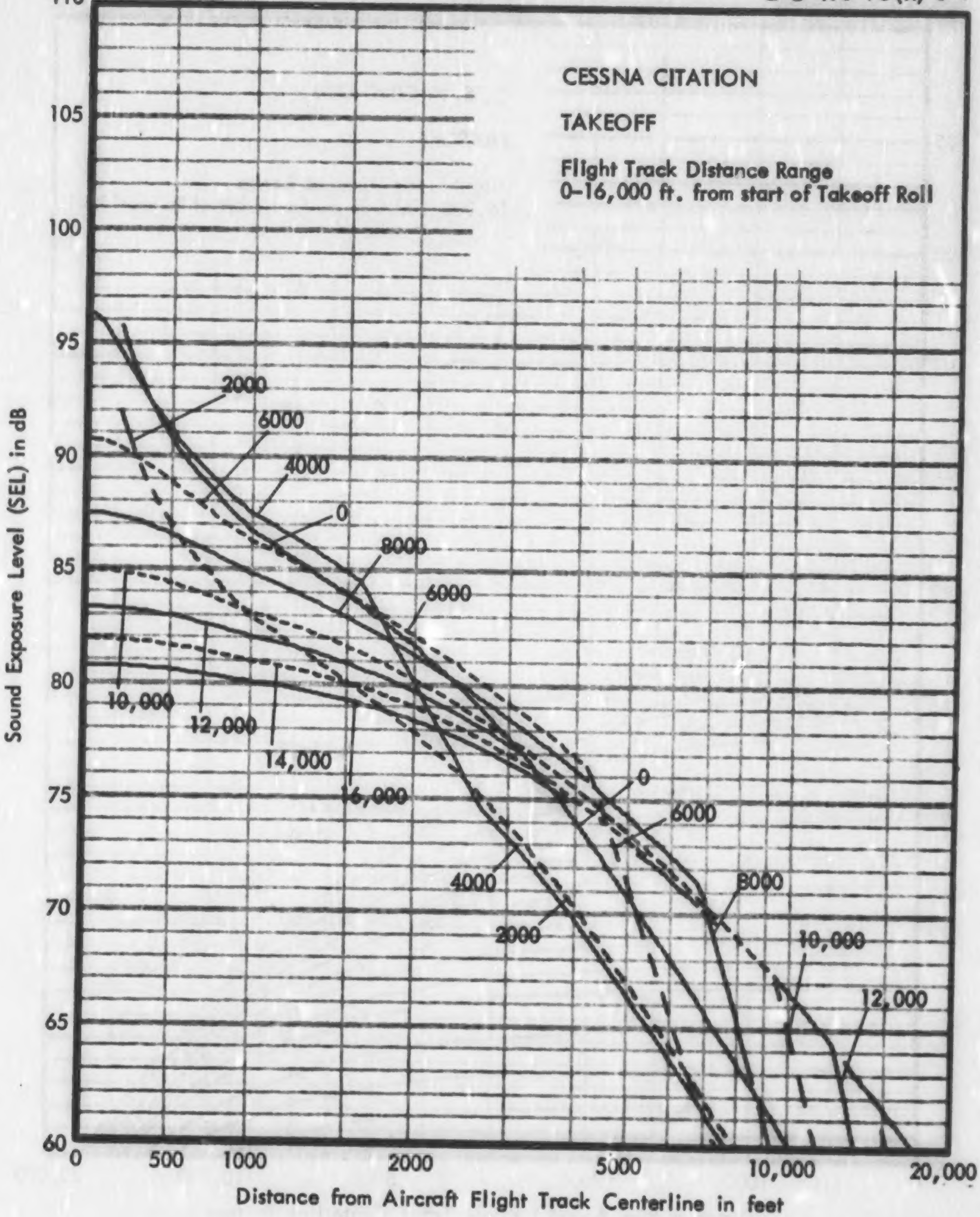


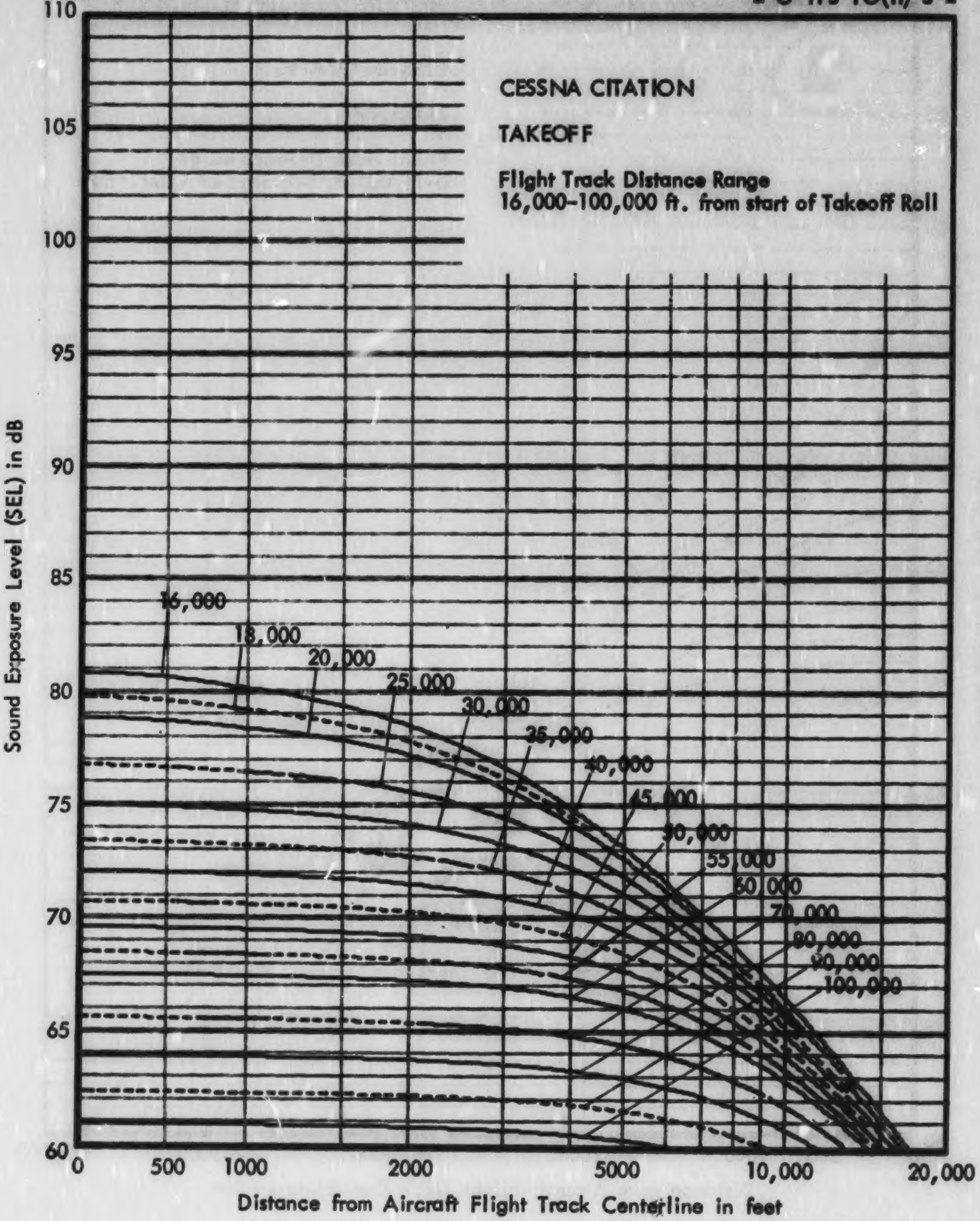
COMPOSITE BUSINESS JET

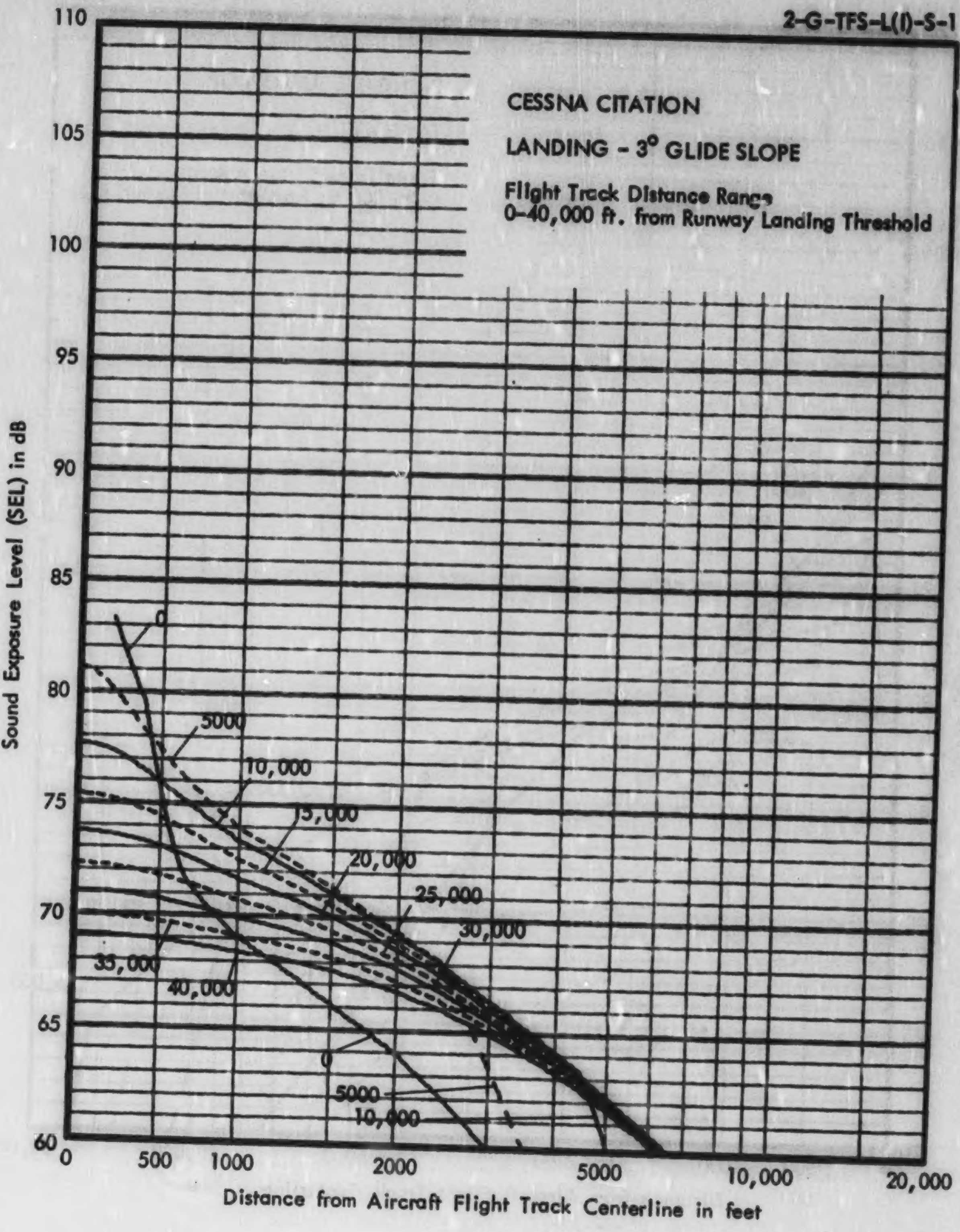
LANDING - 3° GLIDE SLOPE

Flight Track Distance Range
35,000-150,000 ft. from Runway Landing Threshold

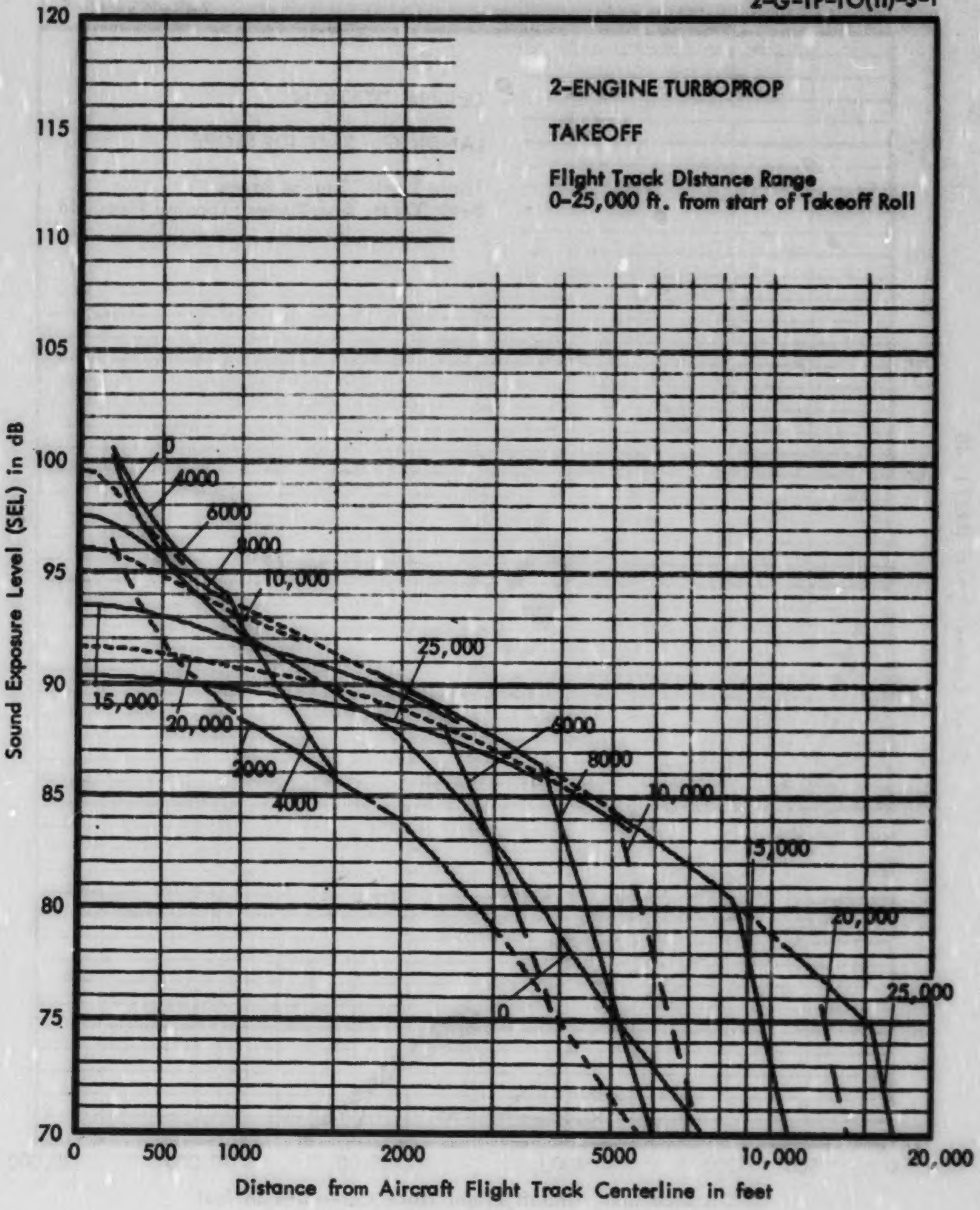
2-G-TFS-TO(II)-S-1



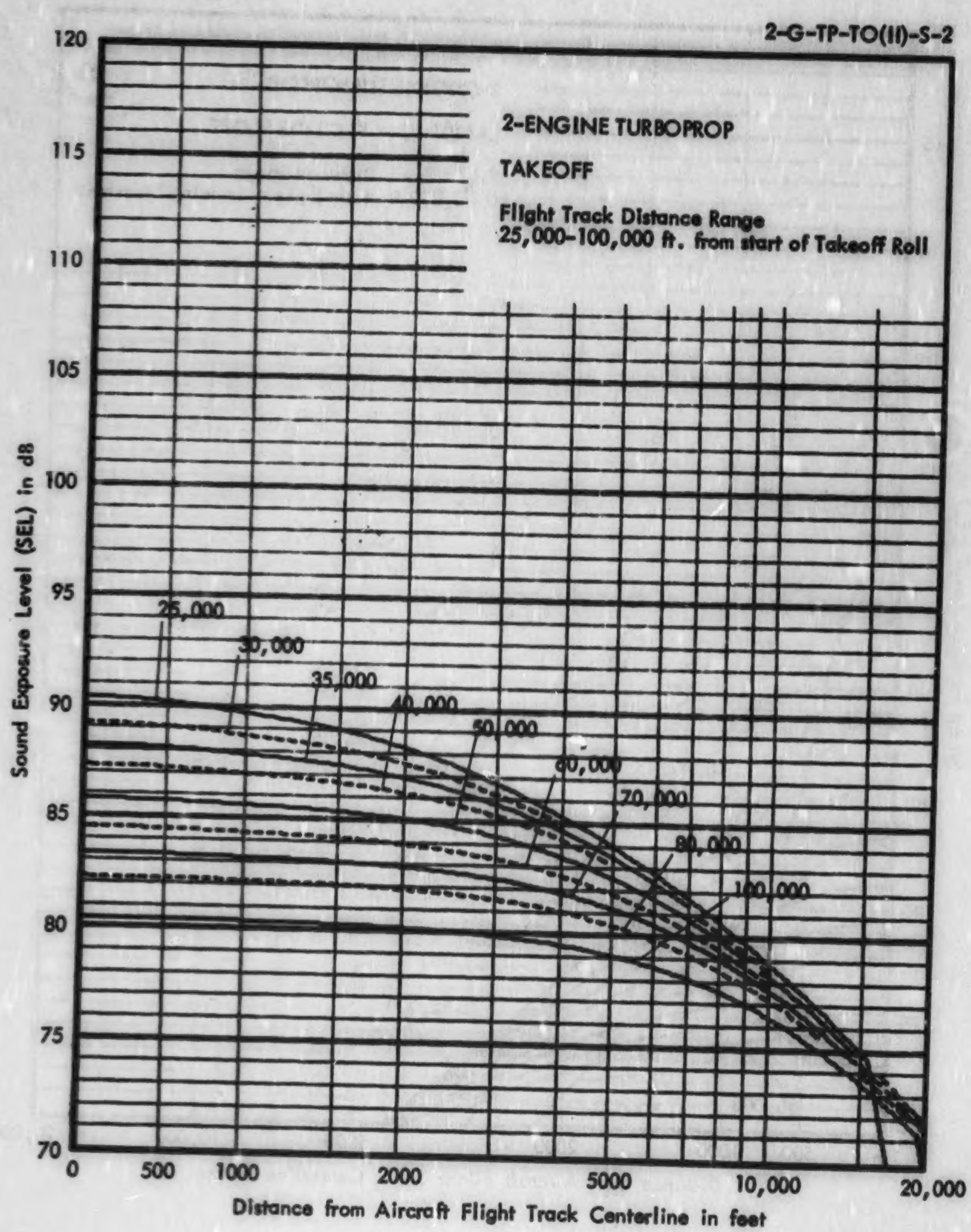

CESSNA CITATION
TAKEOFF
Flight Track Distance Range
16,000-100,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
110
105
100
95
90
85
80
75
70
65
60
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
16,000
18,000
20,000
25,000
30,000
35,000
40,000
45,000
50,000
55,000
60,000
70,000
80,000
90,000
100,000

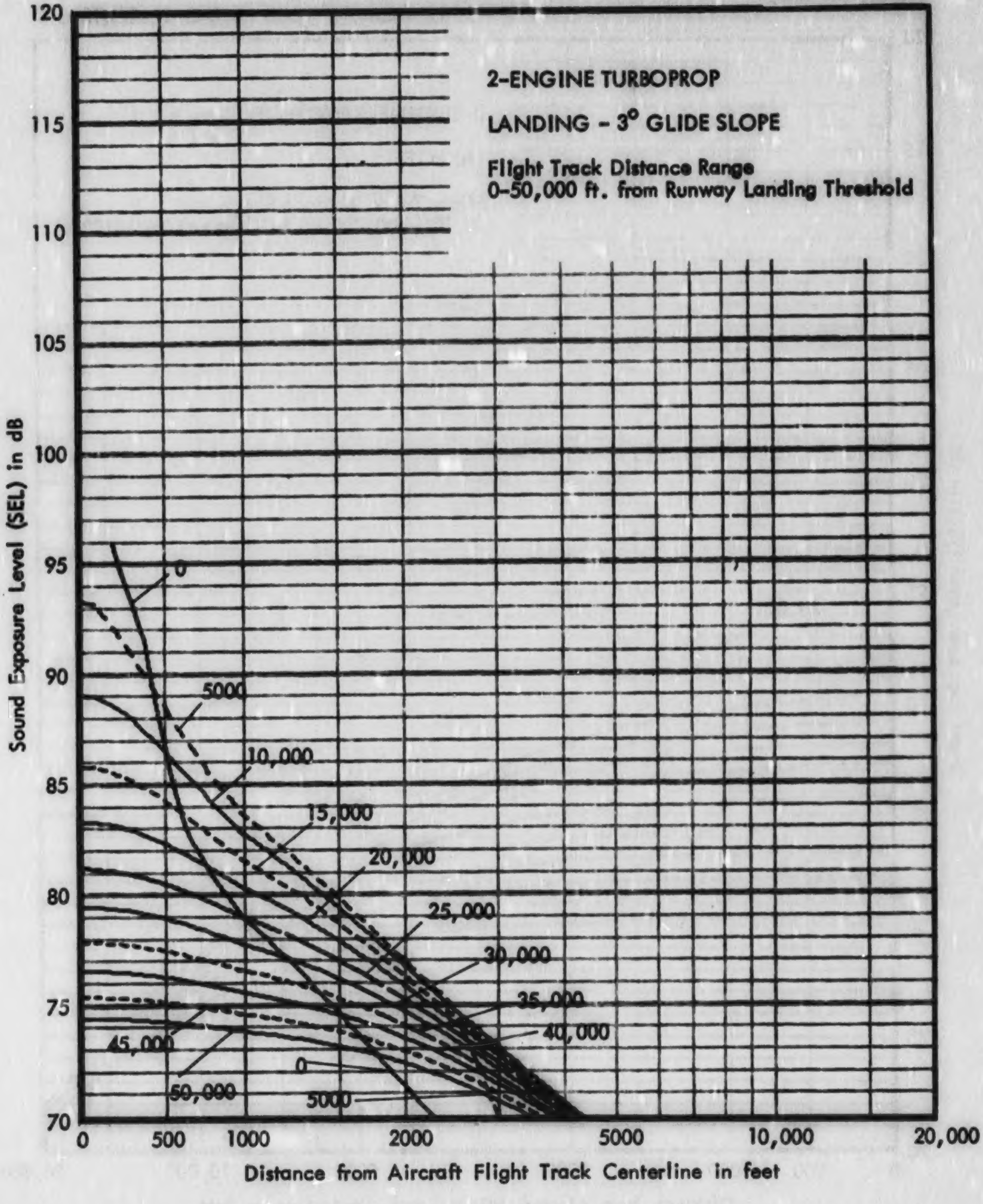

CESSNA CITATION
LANDING - 3° GLIDE SLOPE
Flight Track Distance Range
0-40,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
110
105
100
95
90
85
80
75
70
65
60
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
0
5000
10,000

2-G-TP-TO(II)-S-1


2-ENGINE TURBOPROP
TAKEOFF
Flight Track Distance Range
0-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
Distance from Aircraft Flight Track Centerline in feet
0
500
1000
2000
5000
10,000
20,000
0
4000
6000
8000
10,000
25,000
15,000
20,000
2000
4000
6000
8000
10,000
15,000
20,000
25,000
0

2-G-TP-TO(II)-S-2


2-ENGINE TURBOPROP
TAKEOFF
Flight Track Distance Range
25,000-100,000 ft. from start of Takeoff Roll
25,000
30,000
35,000
40,000
50,000
60,000
70,000
80,000
100,000
120
115
110
105
100
95
90
85
80
75
70
Sound Exposure Level (SEL) in dB
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

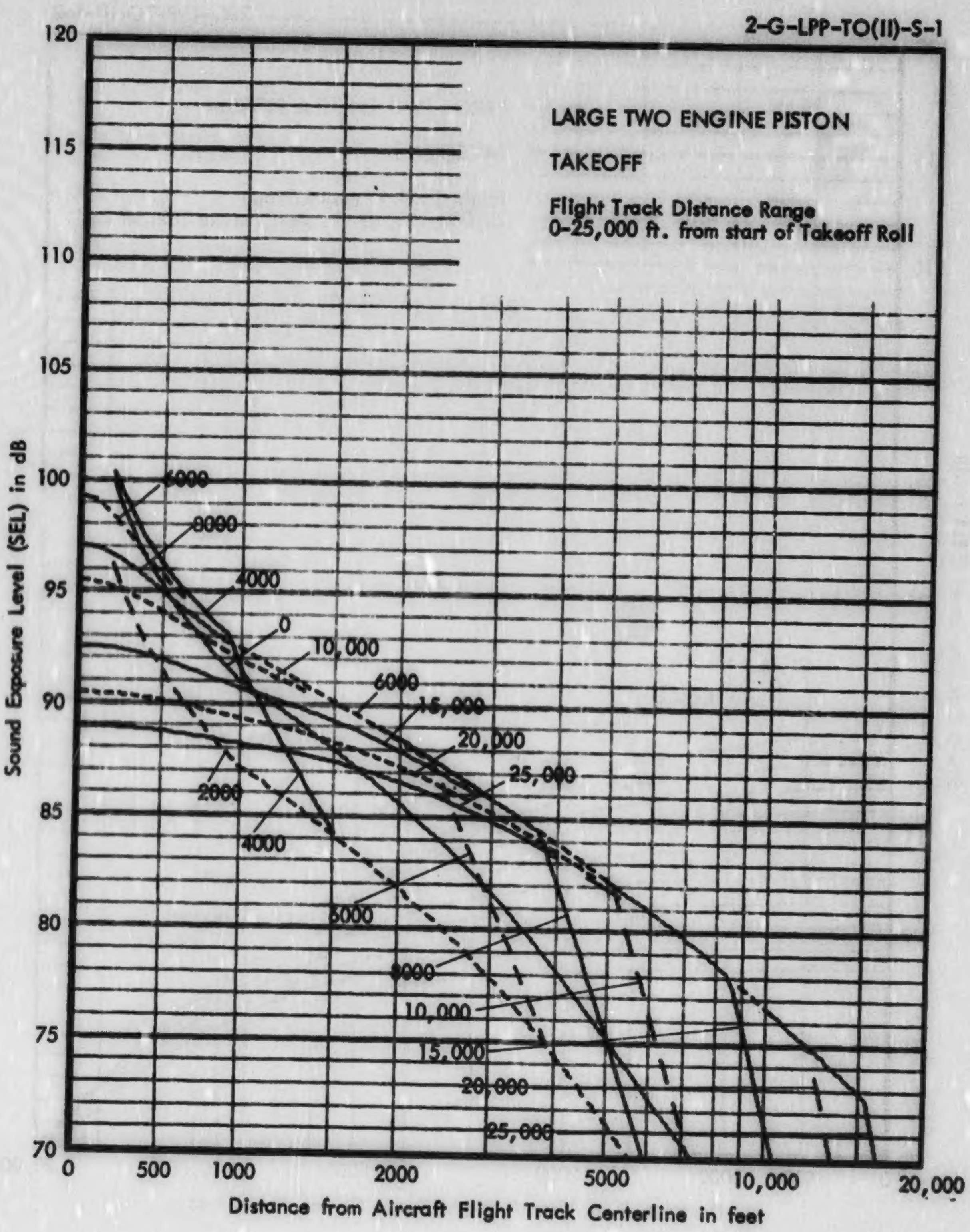


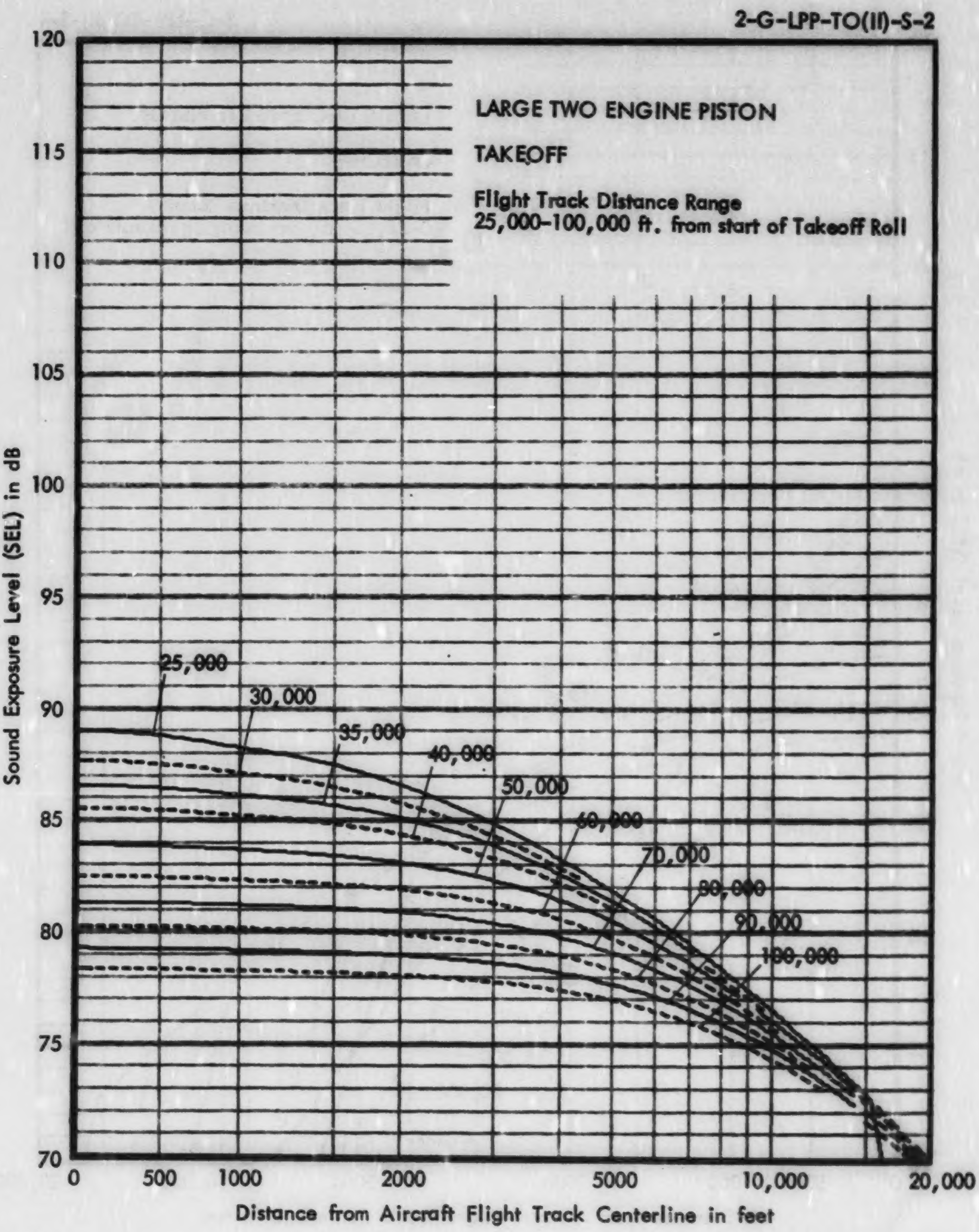
2-ENGINE TURBOPROP

LANDING - 3° GLIDE SLOPE

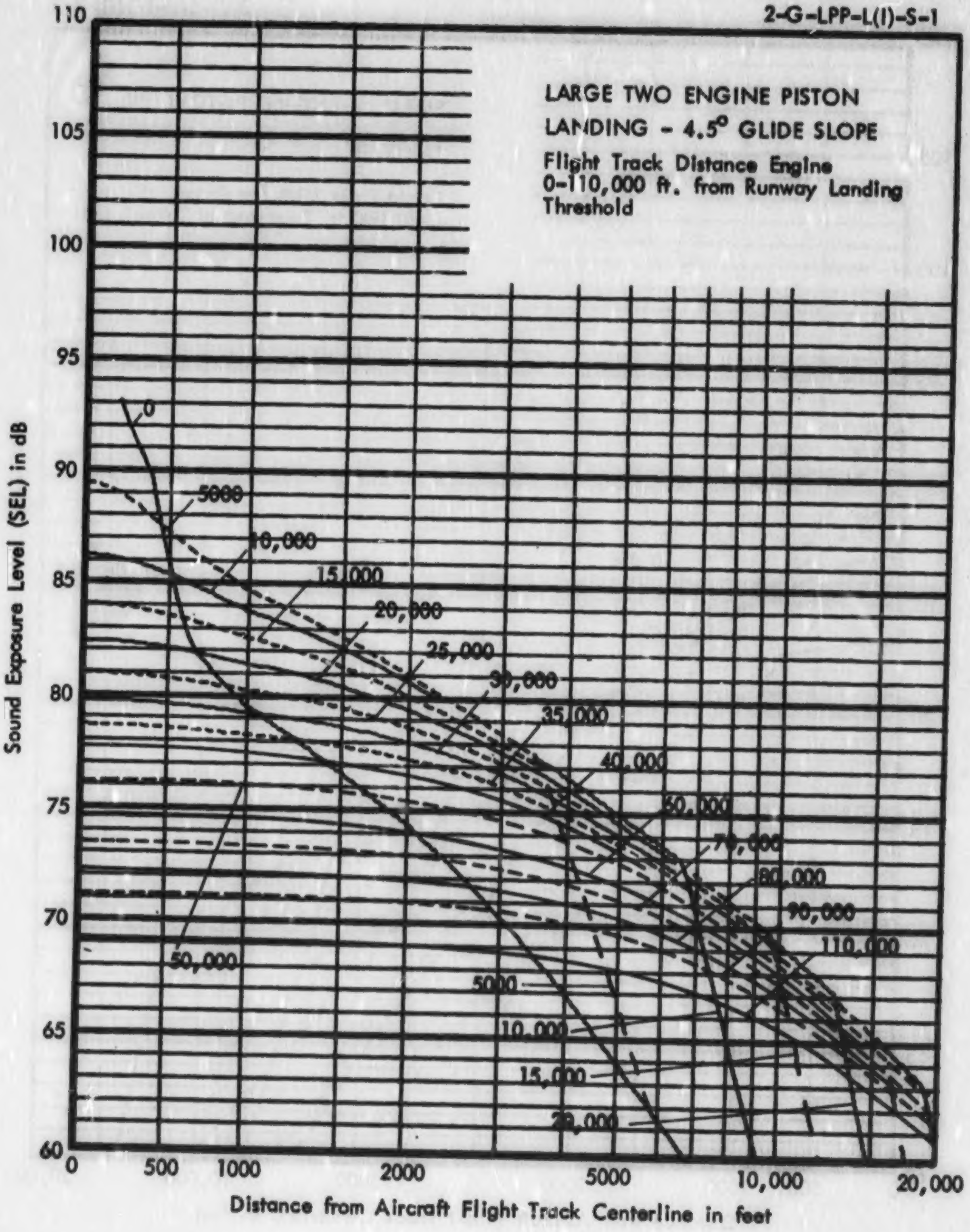
Flight Track Distance Range
0-50,000 ft. from Runway Landing Threshold

2-G-LPP-TO(II)-S-1

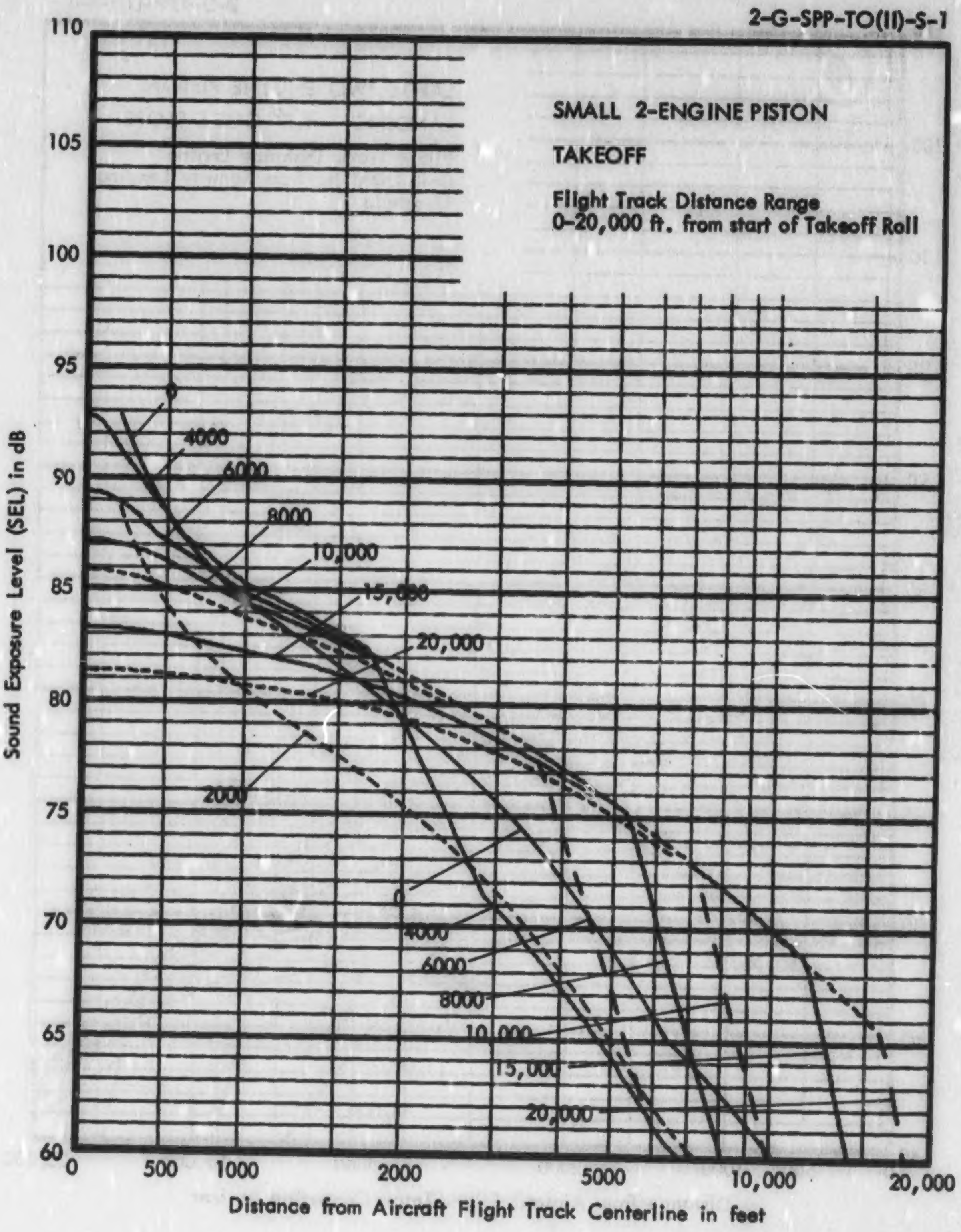



LARGE TWO ENGINE PISTON
TAKEOFF
Flight Track Distance Range
25,000-100,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
120
115
110
105
100
95
90
85
80
75
70
25,000
30,000
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

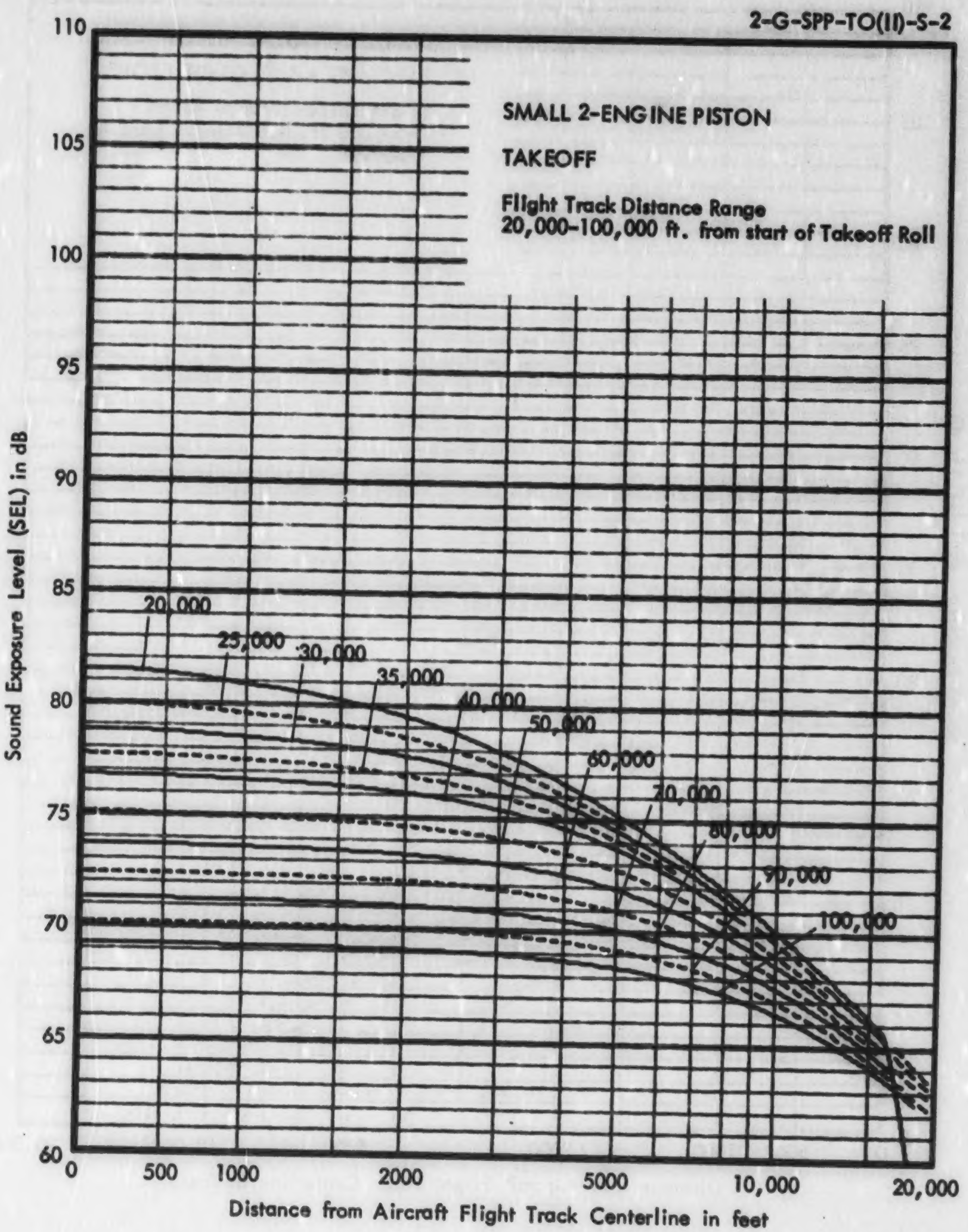
2-G-LPP-L(I)-S-1


LARGE TWO ENGINE PISTON
LANDING - 4.5° GLIDE SLOPE
Flight Track Distance Engine
0-110,000 ft. from Runway Landing Threshold
Sound Exposure Level (SEL) in dB
Distance from Aircraft Flight Track Centerline in feet
110
105
100
95
90
85
80
75
70
65
60
0
500
1000
2000
5000
10,000
20,000
0
5000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
50,000
70,000
80,000
90,000
110,000
50,000
5000
10,000
15,000
20,000

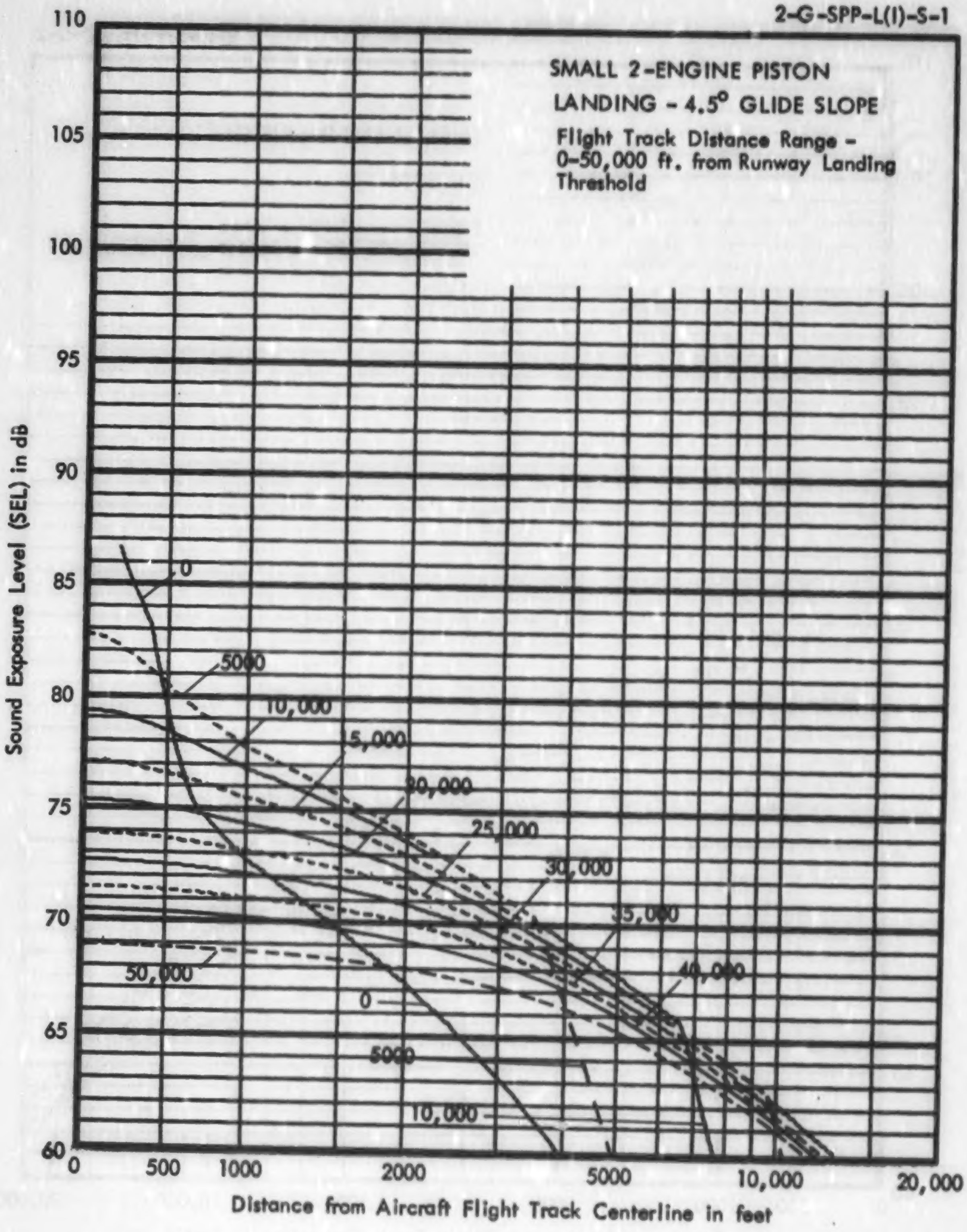
2-G-SPP-TO(II)-S-1



2-G-SPP-TO(II)-S-2



2-G-SPP-L(I)-S-1

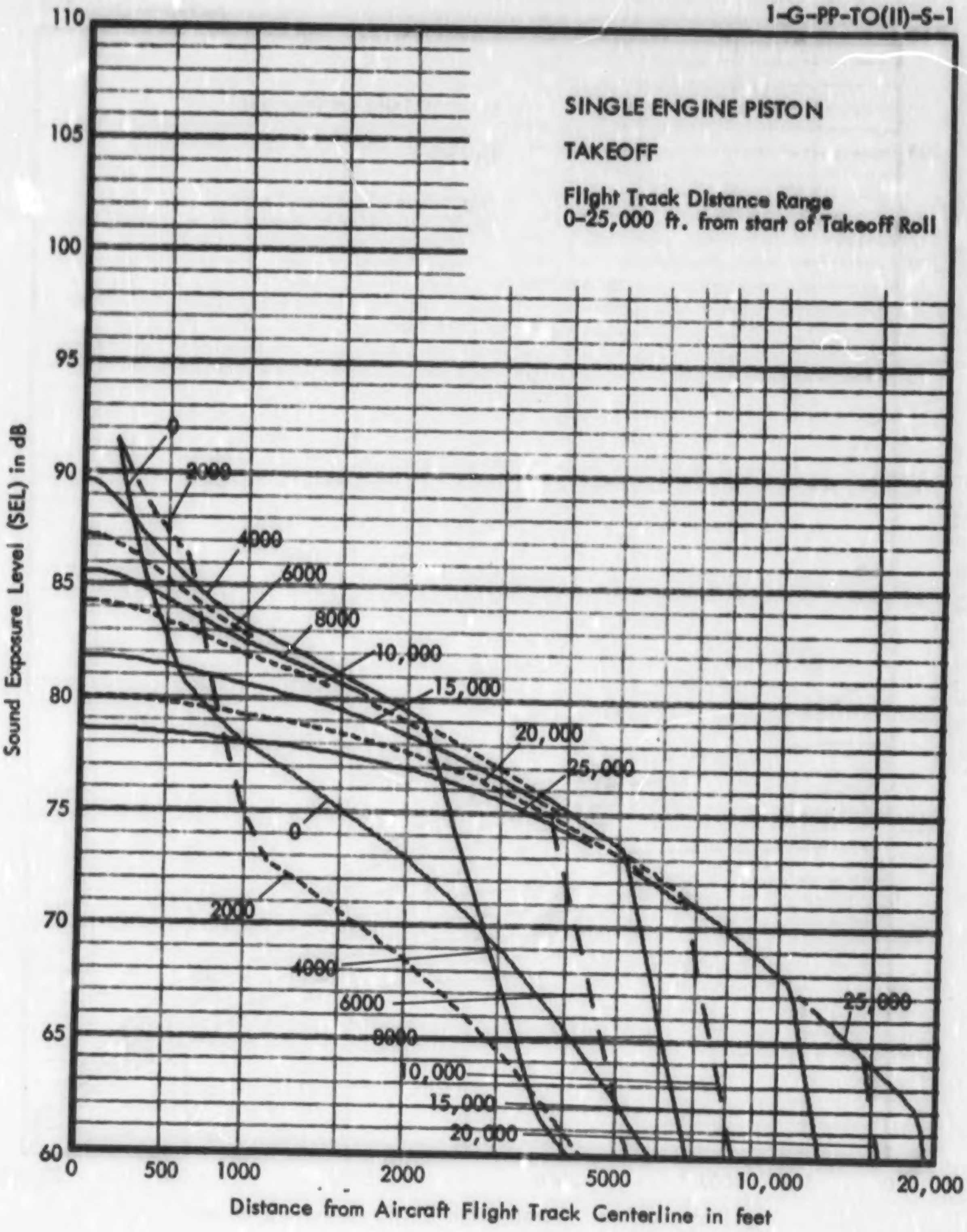


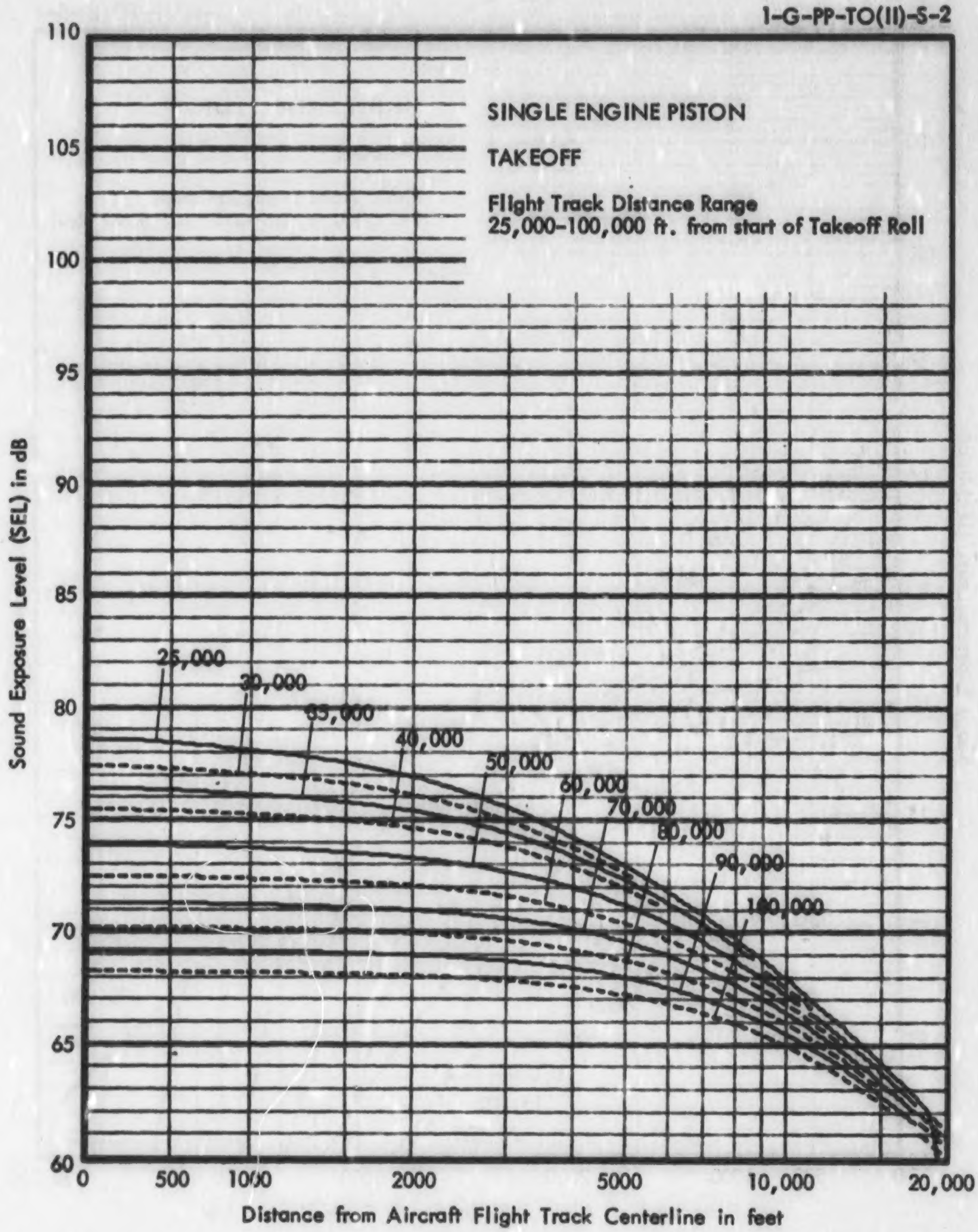
SMALL 2-ENGINE PISTON

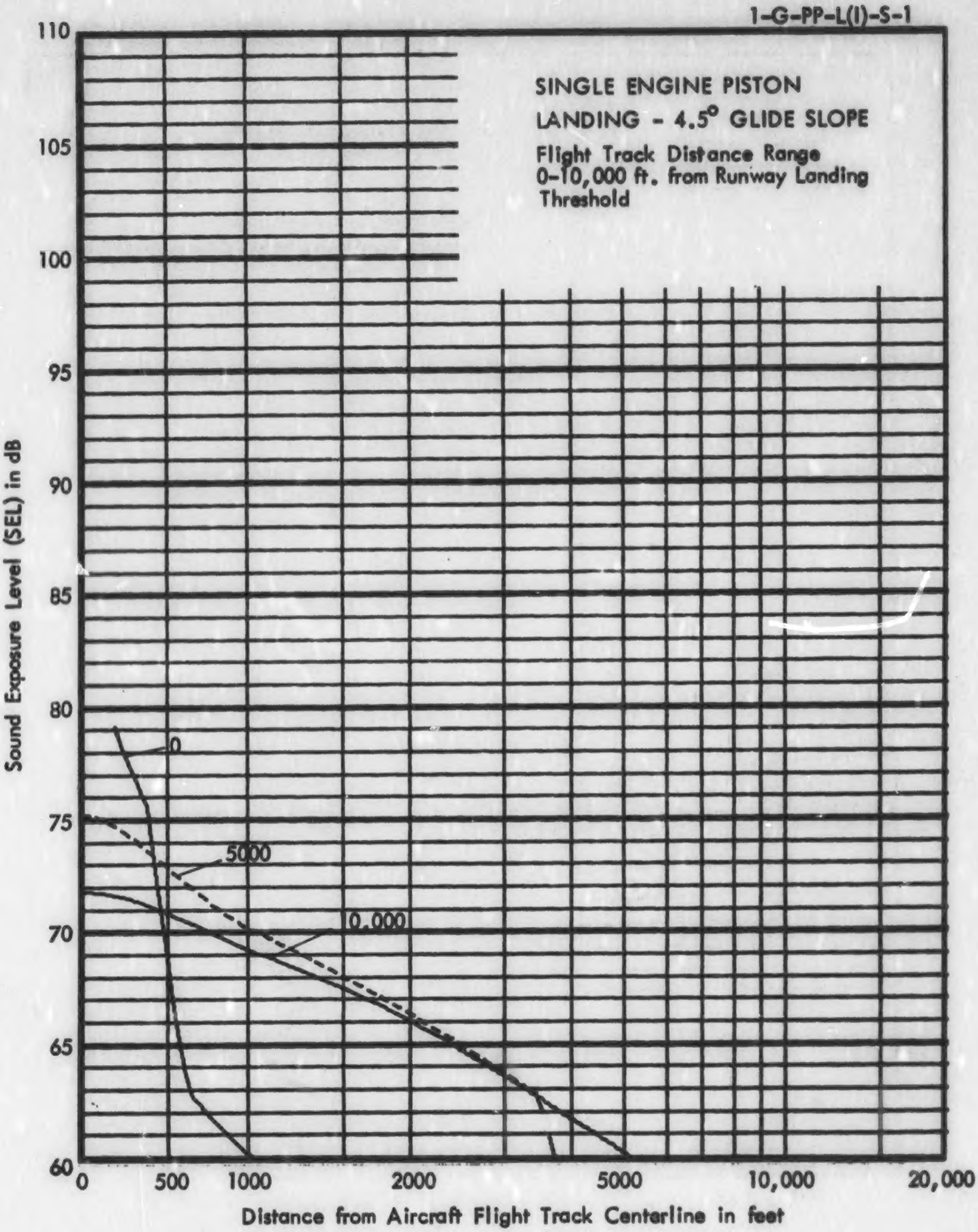
LANDING - 4.5° GLIDE SLOPE

Flight Track Distance Range - 0-50,000 ft. from Runway Landing Threshold

1-G-PP-TO(II)-S-1


SINGLE ENGINE PISTON
TAKEOFF
Flight Track Distance Range
0-25,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
110
105
100
95
90
85
80
75
70
65
60
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet
0
2000
4000
6000
8000
10,000
15,000
20,000
25,000
0
2000
4000
6000
8000
10,000
15,000
20,000
25,000


SINGLE ENGINE PISTON
TAKEOFF
Flight Track Distance Range
25,000-100,000 ft. from start of Takeoff Roll
Sound Exposure Level (SEL) in dB
110
105
100
95
90
85
80
75
70
65
60
25,000
30,000
35,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet


SINGLE ENGINE PISTON
LANDING - 4.5° GLIDE SLOPE
Flight Track Distance Range 0-10,000 ft. from Runway Landing Threshold
110
105
100
95
90
85
80
75
70
65
60
Sound Exposure Level (SEL) in dB
0
5000
10,000
0
500
1000
2000
5000
10,000
20,000
Distance from Aircraft Flight Track Centerline in feet

APPENDIX B

DEVELOPMENT OF THE AIRCRAFT SEL CHARTS

This appendix briefly describes the analytical model used to develop the SEL curves presented in this handbook. The appendix also summarizes the noise and aircraft profile information and data sources. More extensive information and details may be found in the noted references.

A. Noise Model Assumptions

The SEL curves given in the handbook were developed from two basic types of information:

(a) Noise level curves showing the variation of SEL values as a function of distance from the aircraft at known air speed and thrust conditions.

(b) Takeoff and landing profiles for each aircraft showing the height of the aircraft above ground as a function of distance from start of takeoff roll (or landing threshold).

From a knowledge of the flight profiles, one can determine the distances between the aircraft and the observer at any point underneath or to one side of the aircraft (see Figure 2, for example). Knowing the altitude and distance of the observer from the ground track (which form two sides of a right-angled triangle), one can calculate the distance from the observer to the aircraft.

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For each aircraft, SEL curves were developed for both air-to-ground and ground-to-ground propagation in accordance with the simple analytic models given in Reference 1. These curves assume air absorption for standard day conditions (59°F and 70 RH), as provided in SAE ARP 866A. The ground-to-ground curves also assumed excess ground absorption and a 5 dB offset to account for partial shielding of the aircraft noise sources at low angles of elevation.

The transition between air-to-ground and ground-to-ground propagation is based upon the angle of elevation between the aircraft at the closest point of approach and ground observer. This angle, θ, is used to determine a transition coefficient, T, where T is a function of θ and varies between 0 and 1.

For θ equal or less than 4.3°, T = 1 and the ground-to-ground propagation curve is used. For angles of θ or greater than or equal 7.2°, T = 0 and the air-to-ground propagation curve is used. For intermediate angles, ($4.3° < \theta < 7.2°$), the following function is used: $T = 2.5 -0.3491 \cdot \theta$.

No correction is used for the possible fuselage shielding effects of multi engine aircraft at ground positions to the side of the aircraft flight track.

These assumptions are identical to those used in the NOISEMAP computer program developed for the Air Force and currently used for both civil and military aircraft L_{dn} calculations.[2] It should be noted that different assumptions as to the transition between air-to-ground ground-to-ground propagation and shielding may be employed in other computer programs.[3]

B. Noise Data

For the larger civil transport aircraft, sets of noise curves (SEL as a function of distance) were available for different engine thrusts and air speeds. At specified points along the flight path, changes were made to basic noise levels to allow for differences in aircraft speed and thrust from the reference conditions. For the smaller aircraft, generalized takeoff and landing noise vs. distance curves were available. Simplified takeoff profiles were used requiring fewer adjustments of noise level data.

The major source of noise data was Reference 4. This information was supplemented by generalized curves for general aviation aircraft provided in Reference 5. Figure B-1 shows a typical set of noise data for one of the larger civil aircraft and Figure B-2 shows a set of a composite data used for the smaller general aviation propeller aircraft.

C. Performance Data

For larger civil aircraft, basic takeoff profiles were developed for different operating gross weights assuming that the aircraft follow ATA procedures. The interpretation of the ATA procedures used in developing these profiles is given in Table B-1. The ATA takeoff procedures used for the transpor aircraft are shown in Figures B-3 through B-7.

For other aircraft, generalized takeoff profiles were employed. These are shown in Figure B-8 and B-9.

A 3° glide slope was assumed for the landing profiles of all jet aircraft and the heavier propeller aircraft. For the smaller general aviation aircraft, a glide slope of 4.5° was assumed.

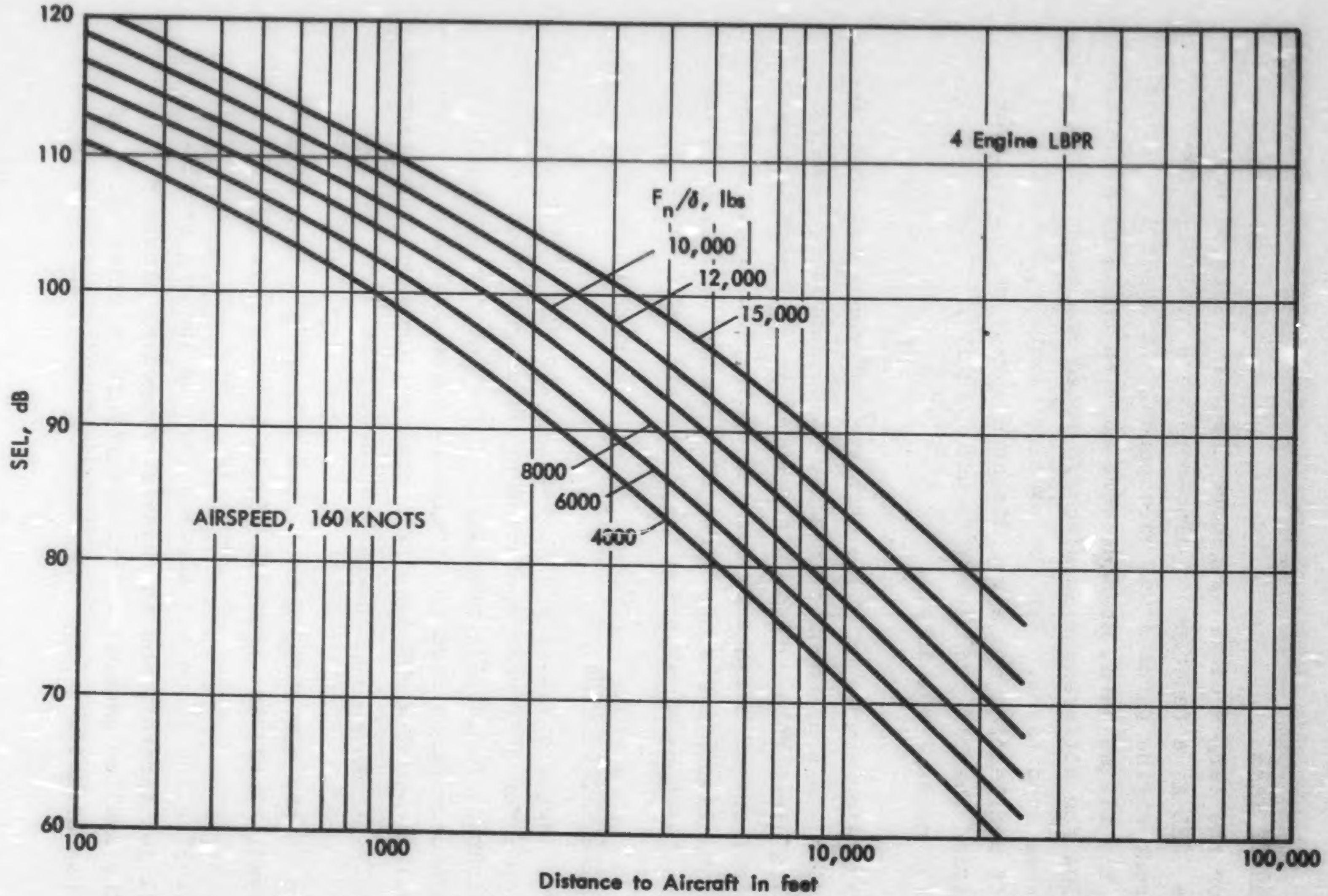

FIGURE B-1. SOUND EXPOSURE LEVEL VERSUS DISTANCE - FOUR ENGINE LBPR TURBOFAN AIRCRAFT - 707 AND DC-8 AIRCRAFT WITH JT3D SERIES ENGINES

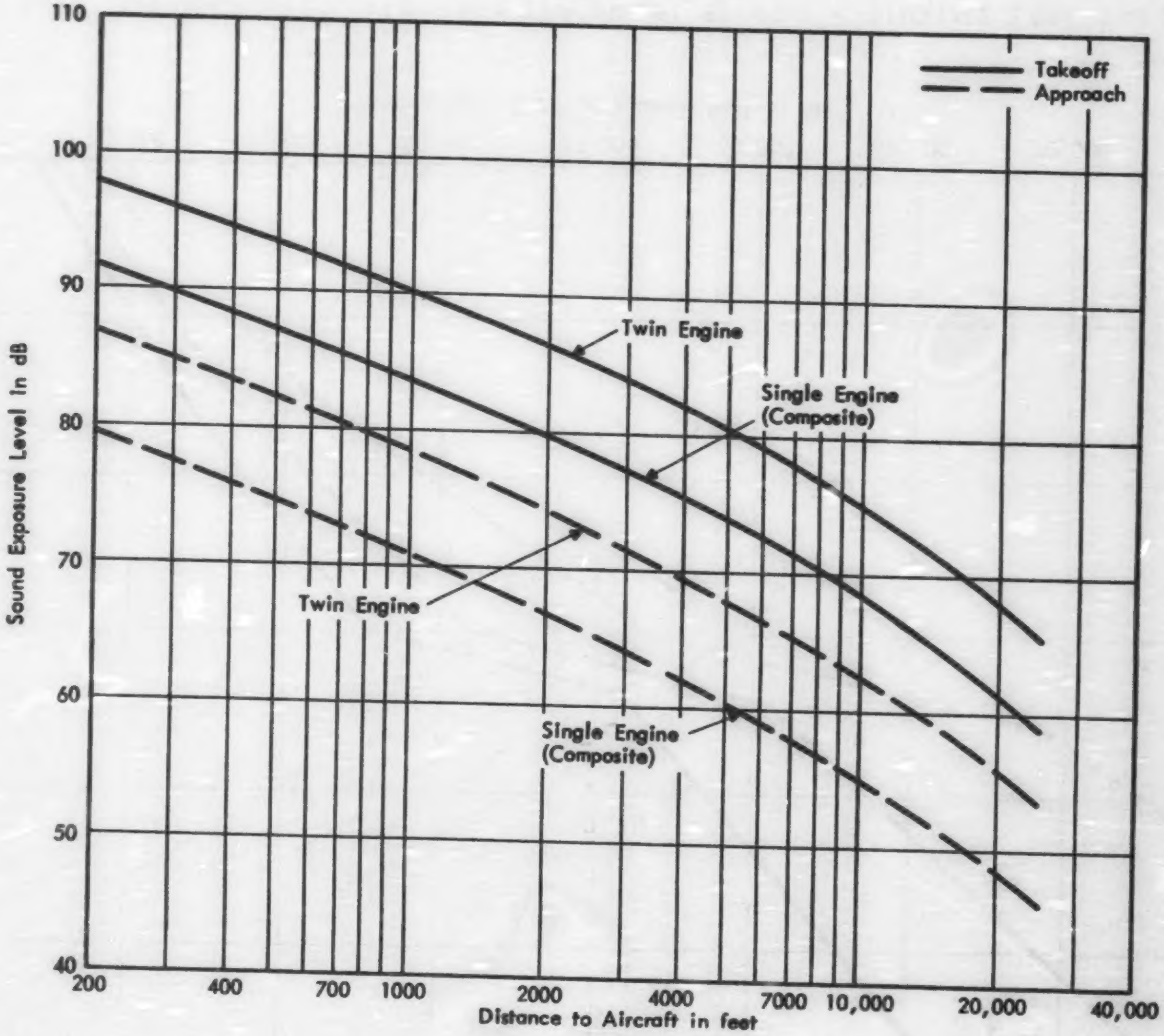

FIGURE B-2. SOUND EXPOSURE LEVEL VERSUS DISTANCE - GENERAL AVIATION PROPELLER AIRCRAFT

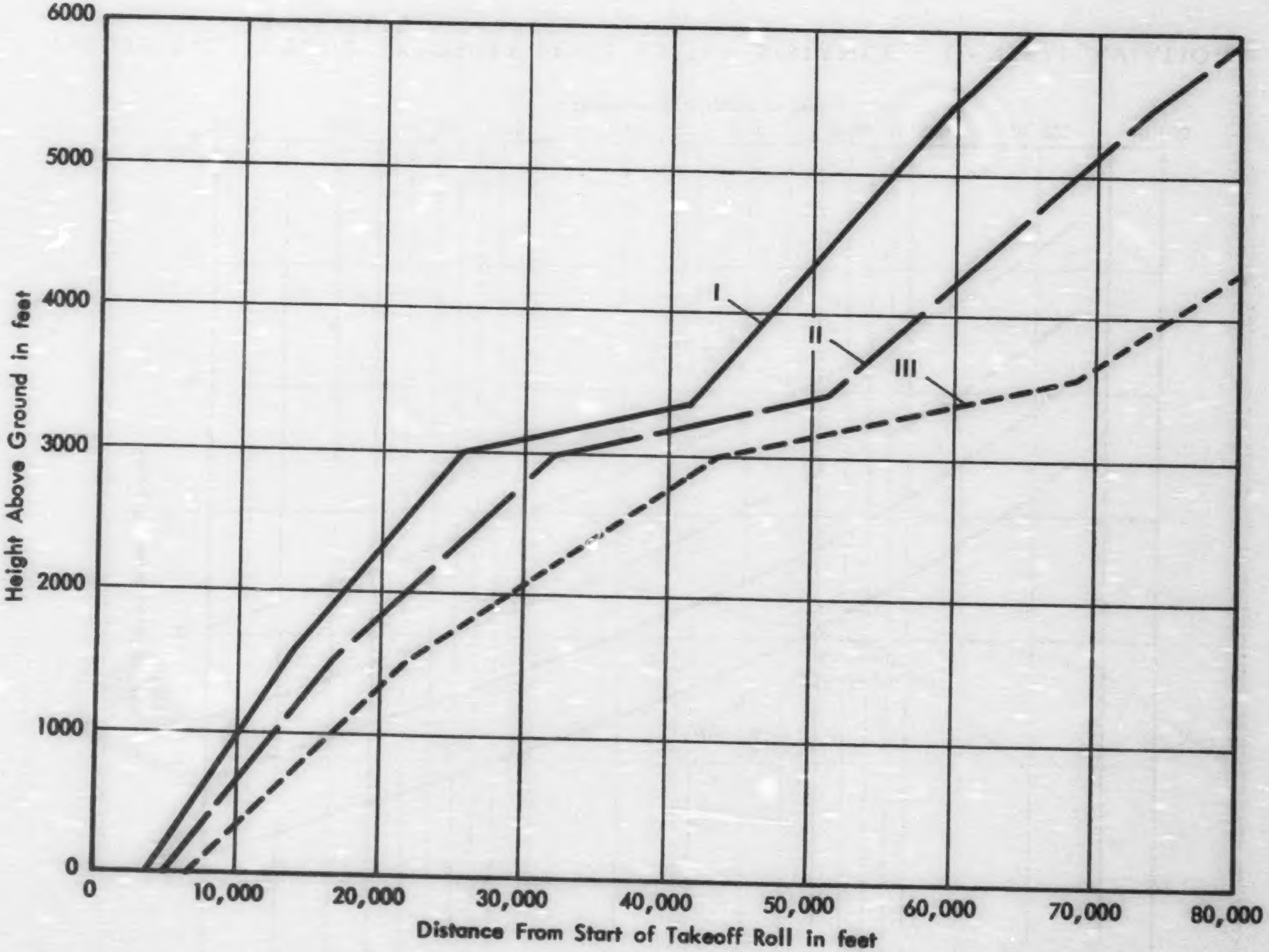

FIGURE B-3. GENERALIZED ATA TAKEOFF PROFILES FOR 4-ENGINE LBPR TURBOFAN TRANSPORT AIRCRAFT - DC-8, 707 SERIES (4-T-TFL)

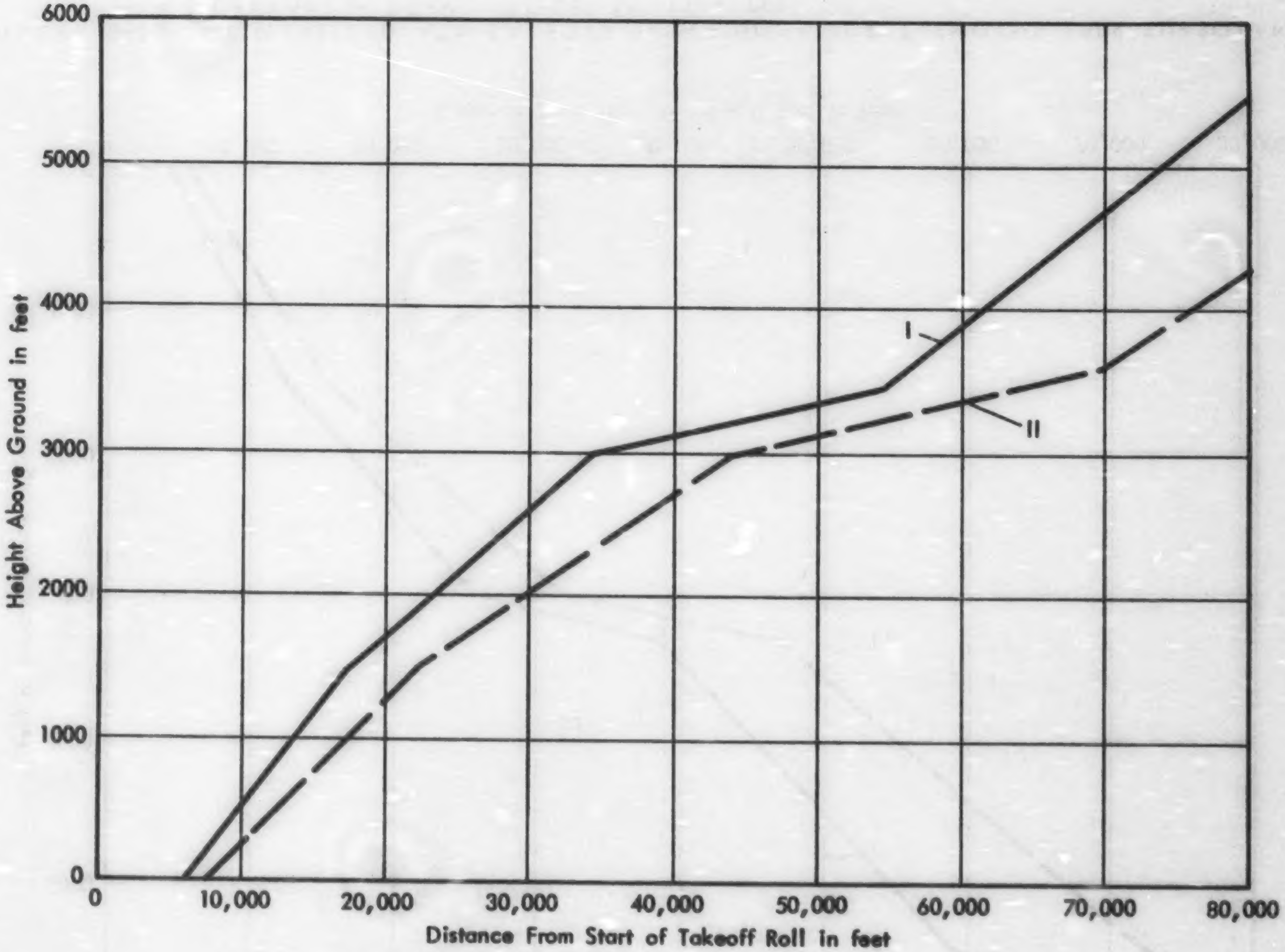

FIGURE B-4. GENERALIZED ATA TAKEOFF PROFILES FOR 3-ENGINE LBPR TURBOFAN TRANSPORT AIRCRAFT - 727 SERIES (3-T-TFL)

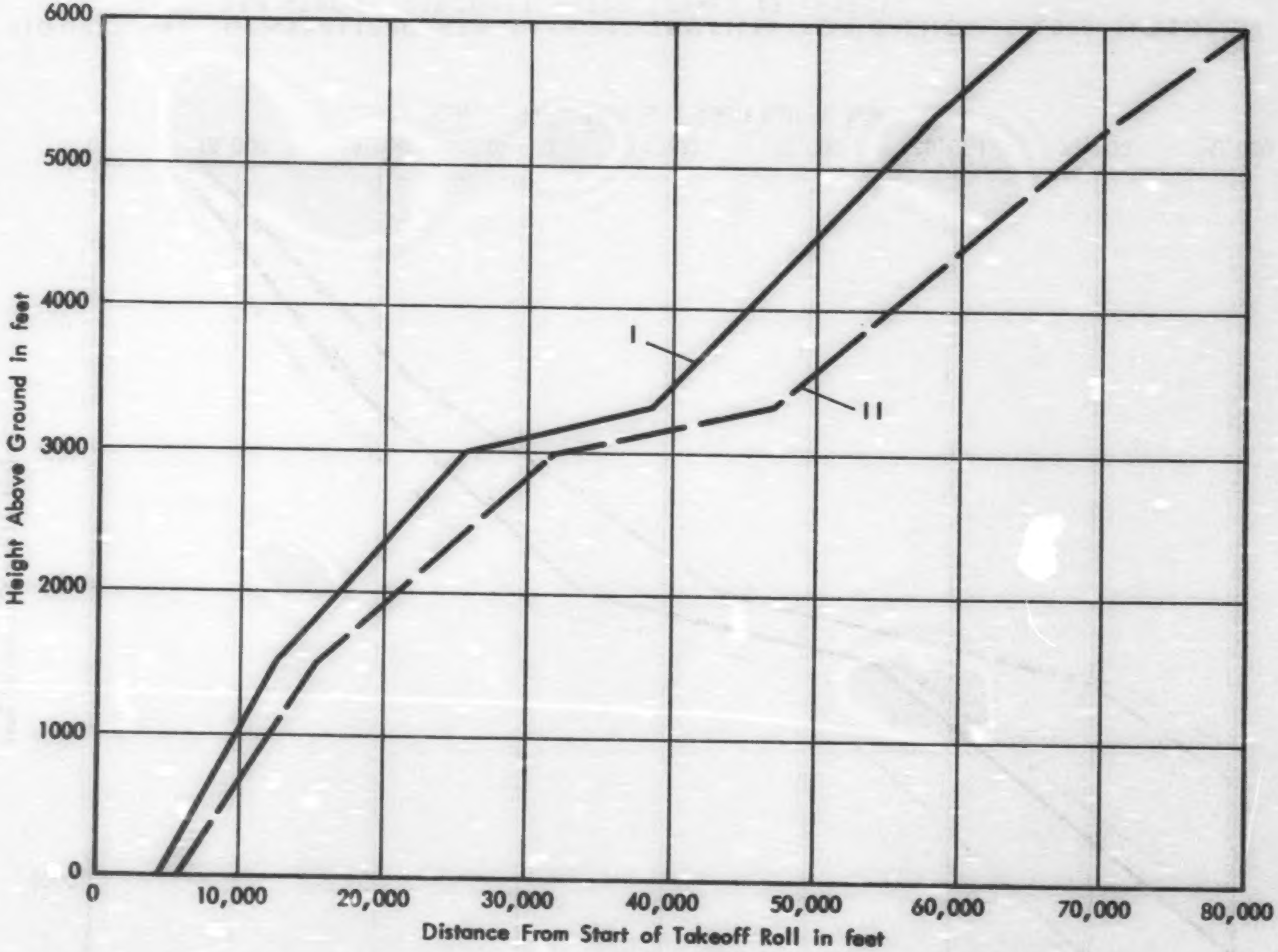

FIGURE B-5. GENERALIZED ATA TAKEOFF PROCEDURES FOR 2-ENGINE LBPR TURBOFAN AIRCRAFT - DC-9, 737 SERIES (2-T-TFL)

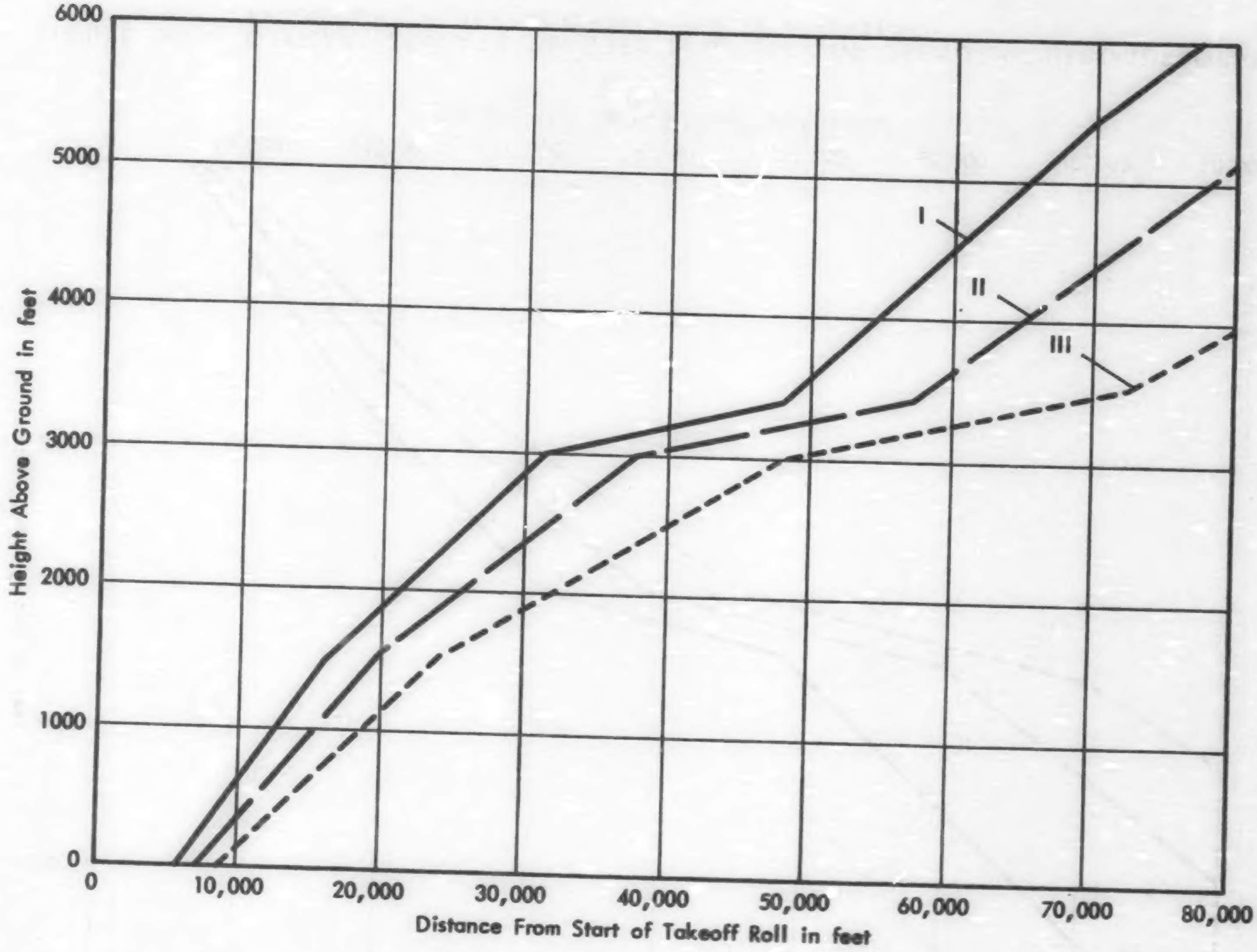

FIGURE B-6. GENERALIZED ATA TAKEOFF PROFILES FOR 4-ENGINE HBPR TURBOFAN TRANSPORT AIRCRAFT - 747 SERIES (4-T-TFH)

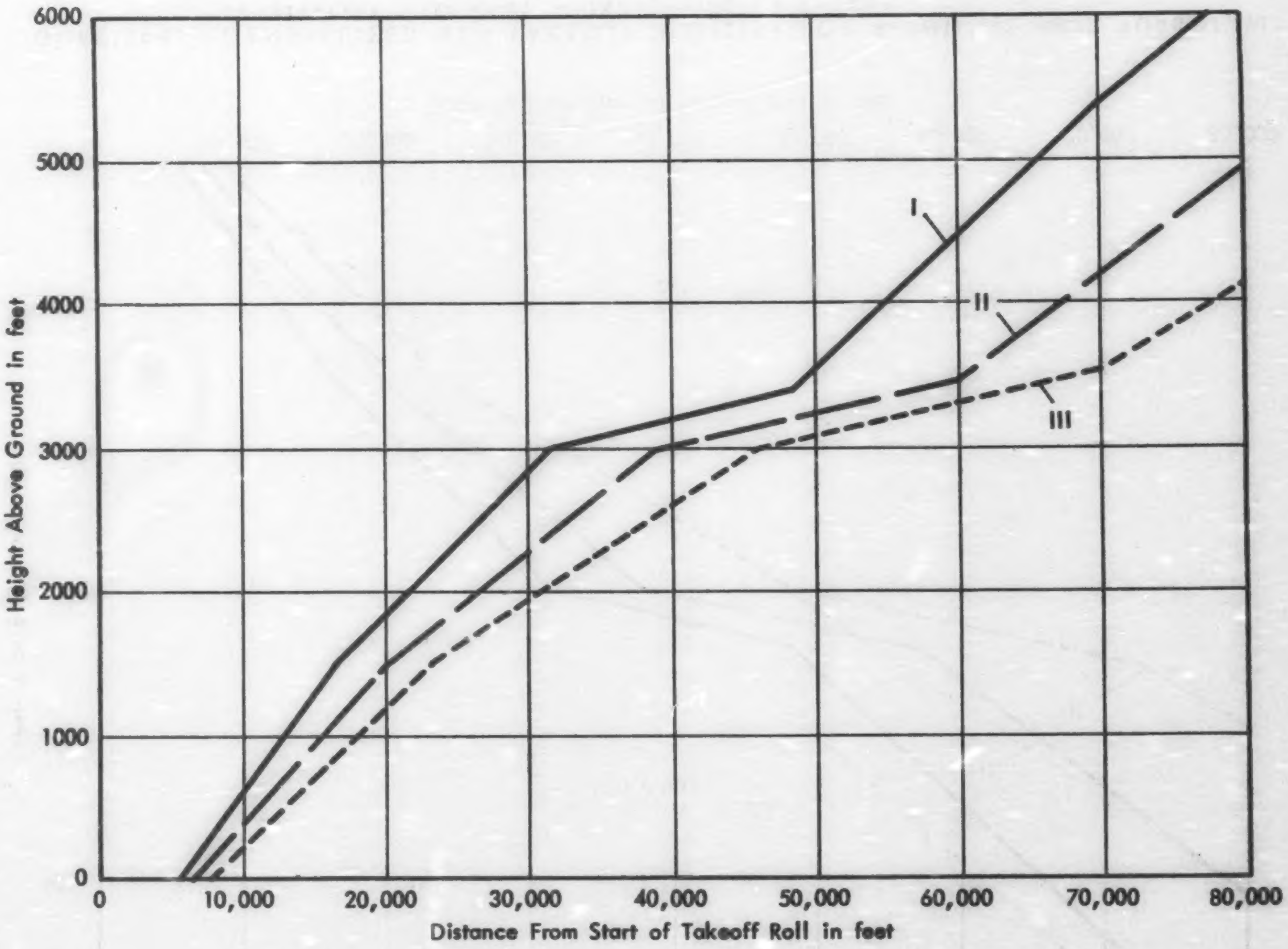

FIGURE B-7. GENERALIZED ATA TAKEOFF PROFILES FOR 3-ENGINE HBPR TURBOFAN TRANSPORT - DC-10, L-1011 SERIES (3-T-TFH)

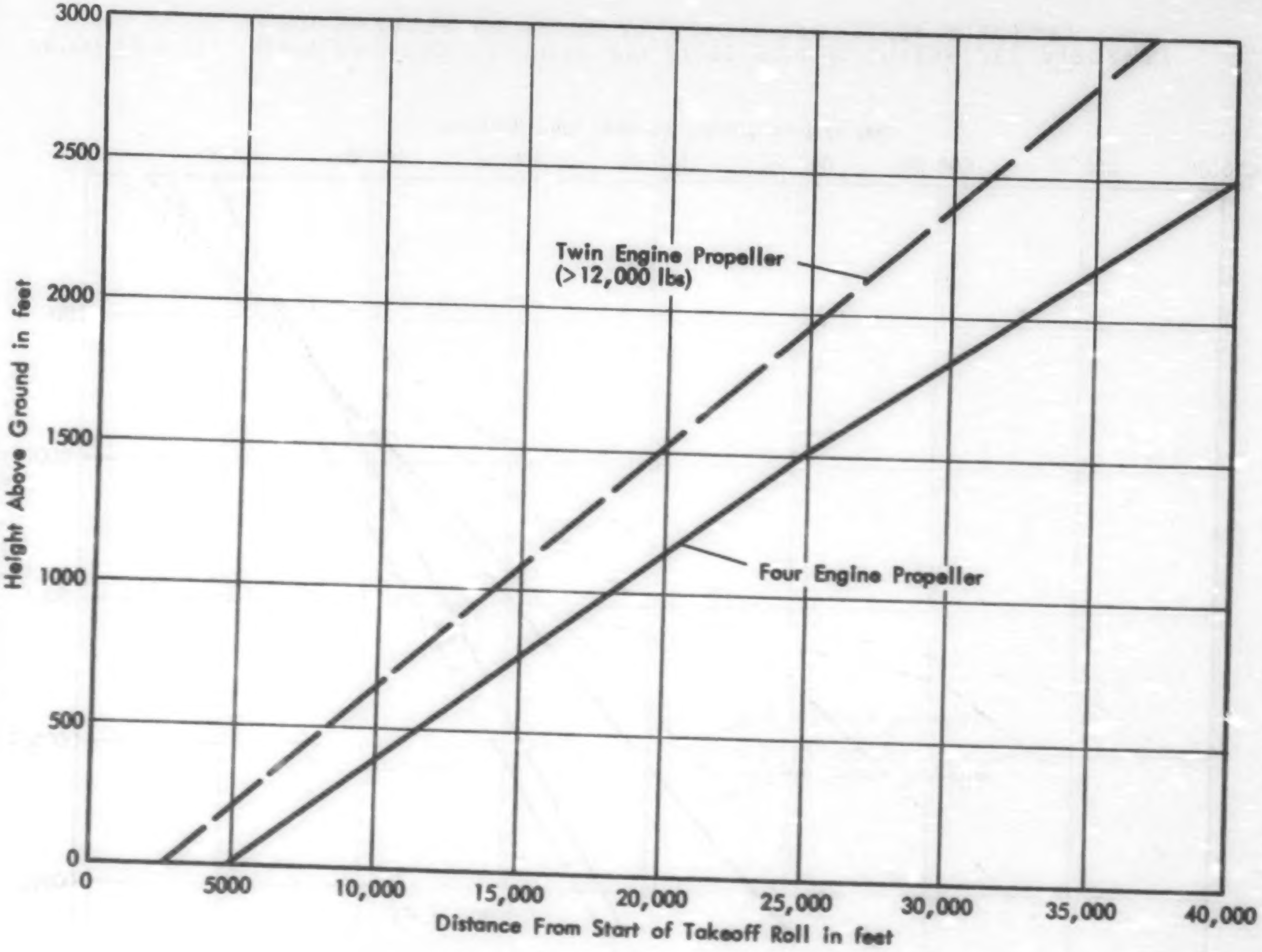

FIGURE B-8. GENERALIZED TAKEOFF PROFILES FOR TWO AND FOUR ENGINE HEAVIER PROPELLER AIRCRAFT

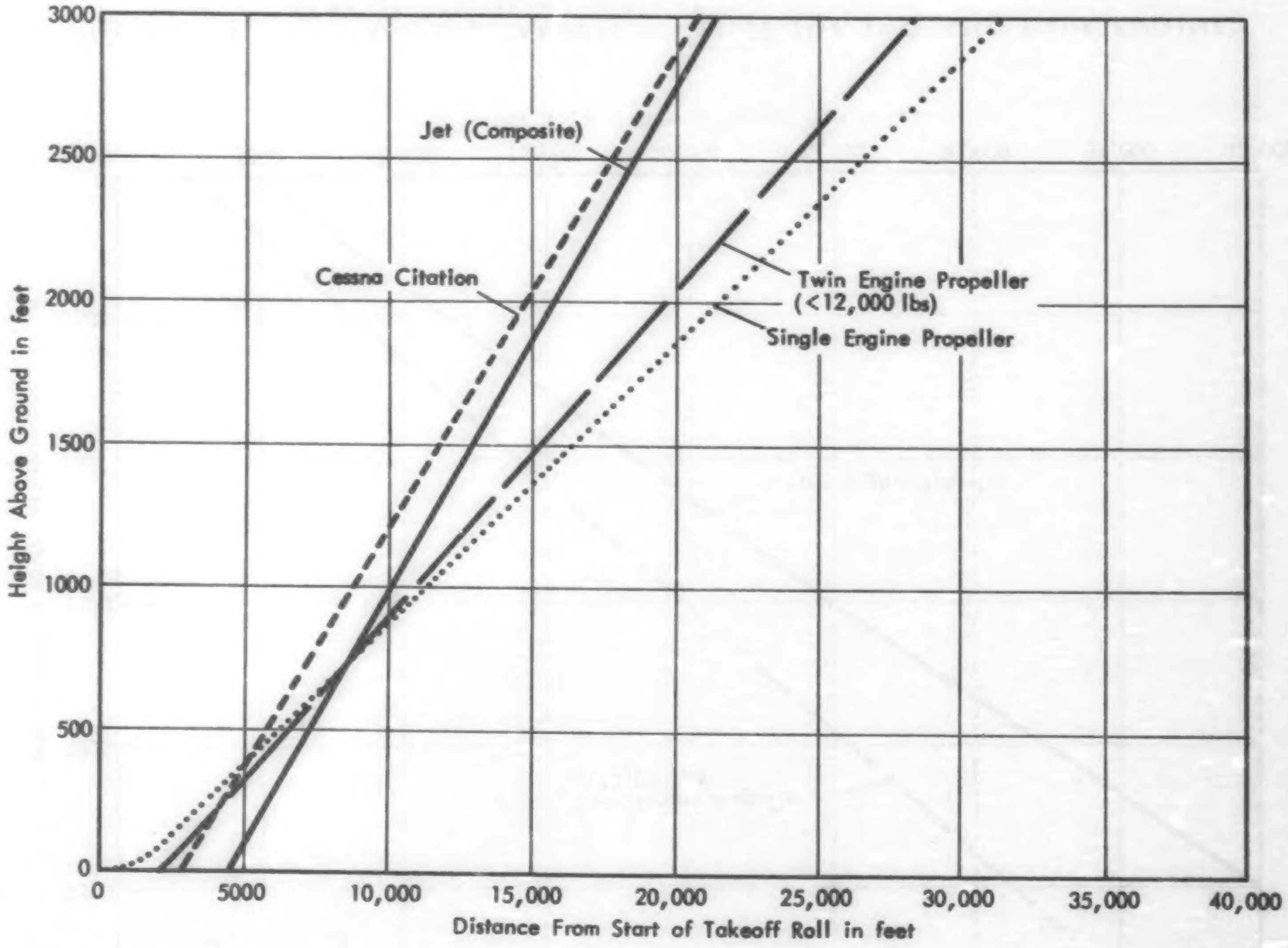

FIGURE B-9. GENERALIZED TAKEOFF PROFILES FOR BUSINESS JET AIRCRAFT AND SMALLER GENERAL AVIATION PROPELLER AIRCRAFT

Reference 1 provides most of the basic data for developing the takeoff profiles and for determining thrusts for the takeoff and landing operations of the larger jet aircraft.

D. Special Takeoff Profiles

For the civil turbofan transport aircraft, SEL curves are provided for two possible noise abatement procedures. One special procedure is based on that development by Northwest Orient Airlines.[7] The other special procedure is based on the allowable thrust cutback permitted by FAR 36.[8] The interpretations of these procedures are given in Table B-1.

Figure B-10 shows a comparison of the three procedures (ATA, NWO Airlines and FAR 36) for a 4-engine LBPR transport aircraft (707/DC-8). It should be noted that the handbook graphs are based on thrust cutbacks at the heights specified in Table B-1. Cutbacks at these heights may not represent the "optimum" noise abatement procedure for alleviating noise at individual airports.

TABLE B-1 TAKEOFF PROCEDURES ASSUMED FOR PROFILES OF CIVIL TURBOFAN TRANSPORT AIRCRAFT

	ATA	Northwest AL	"FAR 36"
First Phase	Takeoff to 1500 ft.	Takeoff to 1000 ft.	Takeoff to 700 ft. (4-engine) or Takeoff to 1000 ft. (2,3-engine)
	Takeoff (TO) thrust V_2 + 10 airspeed TO flaps	TO thrust V_2 + 10 airspeed TO flaps	TO thrust V_2 + 10 airspeed TO flaps
Second Phase	1500 to 3000 ft.	1000 to 3000 ft.	700 ft. or 1000 ft. and Above
	Reduce thrust to maximum climb thrust Maintain V_2 + 10 airspeed and TO flaps.	At 1000 ft., lower nose, accelerate and retract flaps; at V_{ZF}, lower nose, reduce thrust to maintain climb of 1000 FPM[1] and hold V_{ZF} speed.	Reduce thrust to that required for climb gradient of 4% (or that required for level flight with one engine out)[1], maintain V_2 + 10 airspeed and TO flaps.
Third Phase	3000 ft. and Above	3000 ft. and Above	
	Accelerate to 250 Kt, retract flaps on schedule while maintaining 500 FPM climb, then climb at 250 Kt.	Increase to normal climb thrust, accelerate to 250 KT and continue climb.	

1. Engine thrust adjusted for operating gross weight

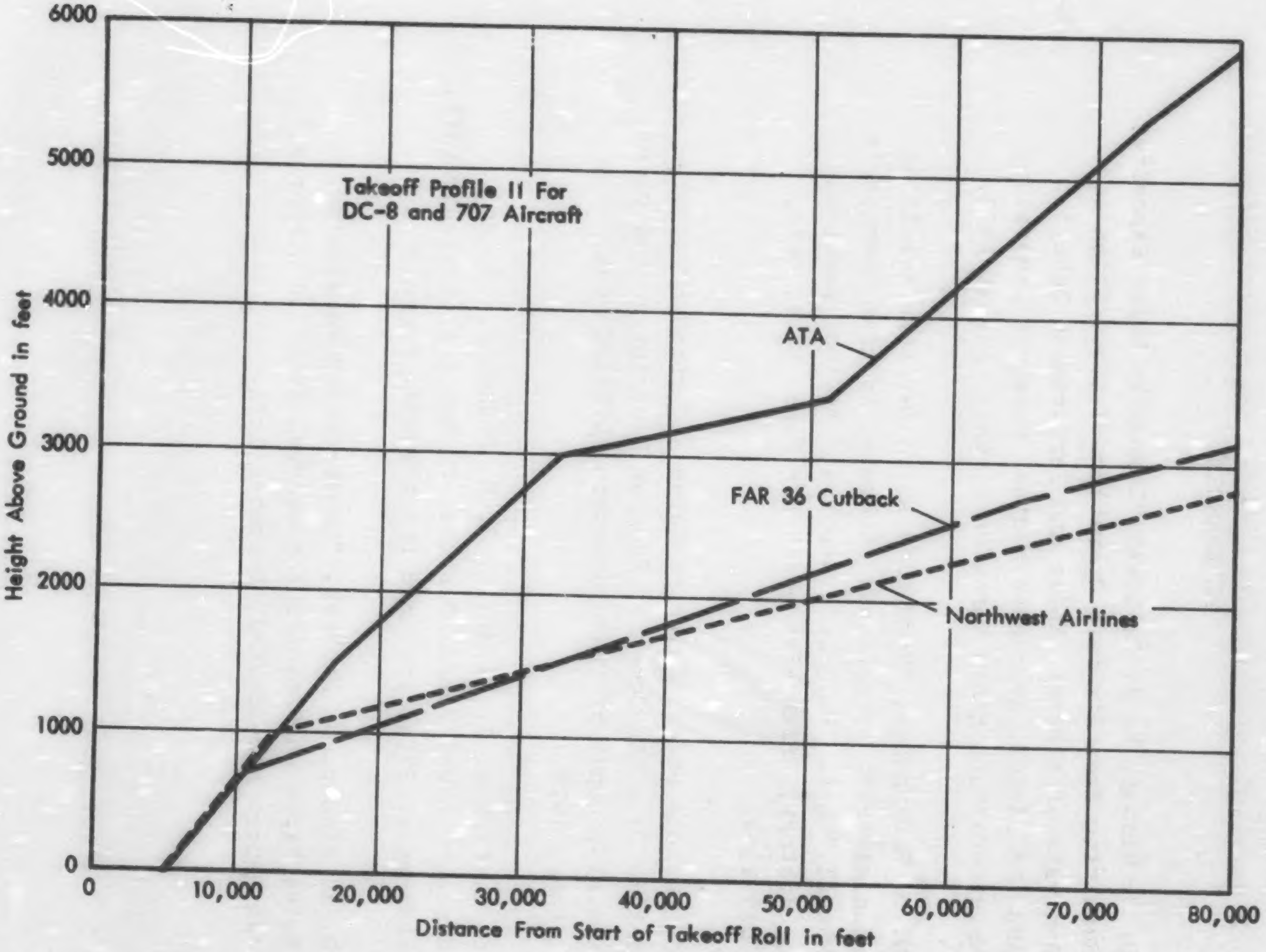

FIGURE B-10. A COMPARISON OF TAKEOFF PROFILES FOR FOUR-ENGINE LBPR TURBOFAN TRANSPORT AIRCRAFT - DC-8, 707 SERIES

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

noise

A method is described for calculating the values of day/night level (L_{dn}), at a point, due to aircraft operations from an airport. Two levels of sophistication are detailed; (1) at the basic level, such factors as type of takeoff and landing procedure are considered, but range and non-standard glide slopes are excluded, (2) the more detailed method takes account of the latter parameters. The procedure used is to locate the position of the point in question, relative to the runway and aircraft flight track. A series of charts give L_{dn} values for different types of aircraft in terms of the distance parameters. Adjustments are made to the single event noise level to account for frequency of operations and the adjusted levels are added logarithmically to represent all of the classes of aircraft using the airport.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Noise levels, aircraft noise levels, day-night average noise levels, noise level prediction, airport noise levels.		

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